

# MS 107

## *Introduction to Modeling and Simulation*



## THE MOVES INSTITUTE



## Naval Postgraduate



## School

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# Questions that Modeling and Simulation 101 will answer for you:

**Where have we been with M&S and how did we get here?**

**What is the DoD role in M&S?**

**What are the key M&S terms and what do they mean?**

**Where is M&S Today ?**

**What is the Common Technical Framework?**

**What are the key DoD M&S programs?**

**What are the benefits and challenges of M&S?**

**How is representation done in M&S?**

**What M&S information sources are available?**

**What is VV&A?**

# Why Modeling and Simulation?

1. To educate, train, communicate.
2. To experience failure at low cost - or create success at less cost.

- risk reduction, covert rehearsal, information security
- safety, protects the environment

3. To expand the world where we can look at a problem.

- change the variables (enemy capabilities, weather, terrain)
- create a realistic environment for training or testing that may be too expensive or too futuristic to do live
- view a complex world





# Why Modeling and Simulation?

## 4. To facilitate communication.

- provides a method for the engineer and the warfighter to exchange information



## 5. To improve efficiency and effectiveness.

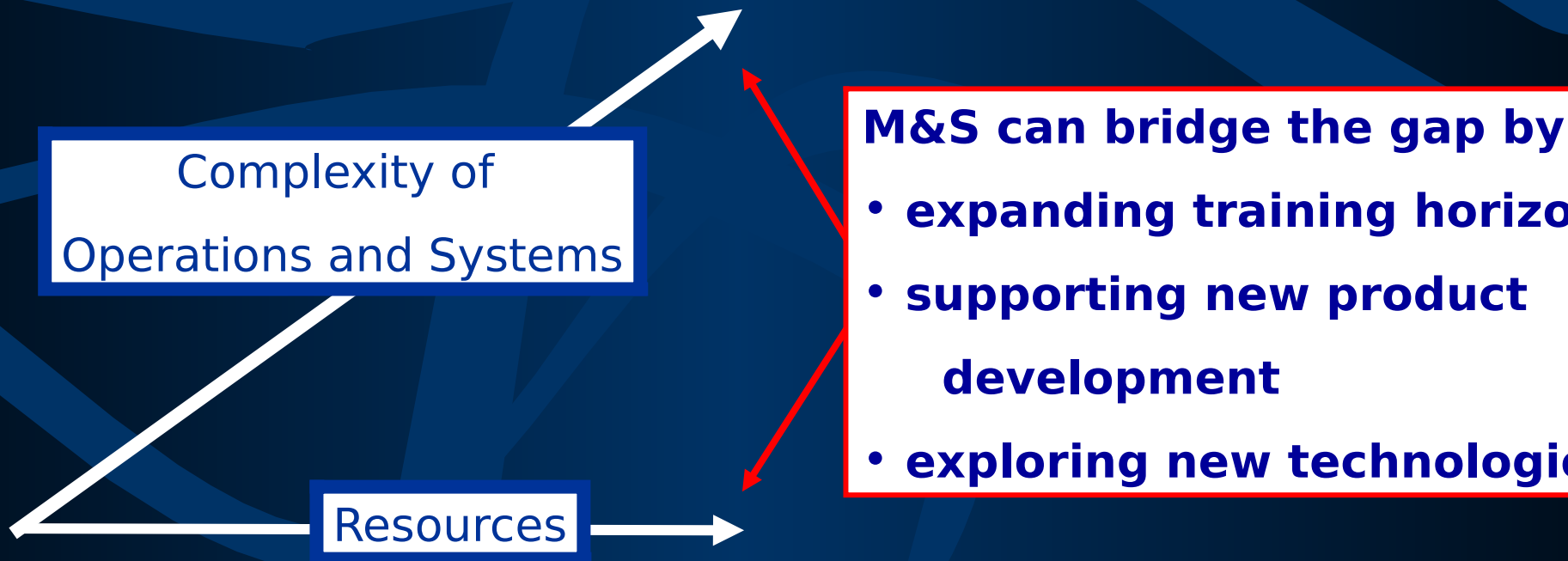
- eliminates need to assemble a team in one location
- provides instructional capability
- speeds the creation of different scenarios, combat areas
- provides a test capability for concepts, strategy, and tactics



# Why Modeling and Simulation?

## The Problem: Complexity

**Increased complexity demands more practice, prototyping, and experimenting which budgets may not permit.**



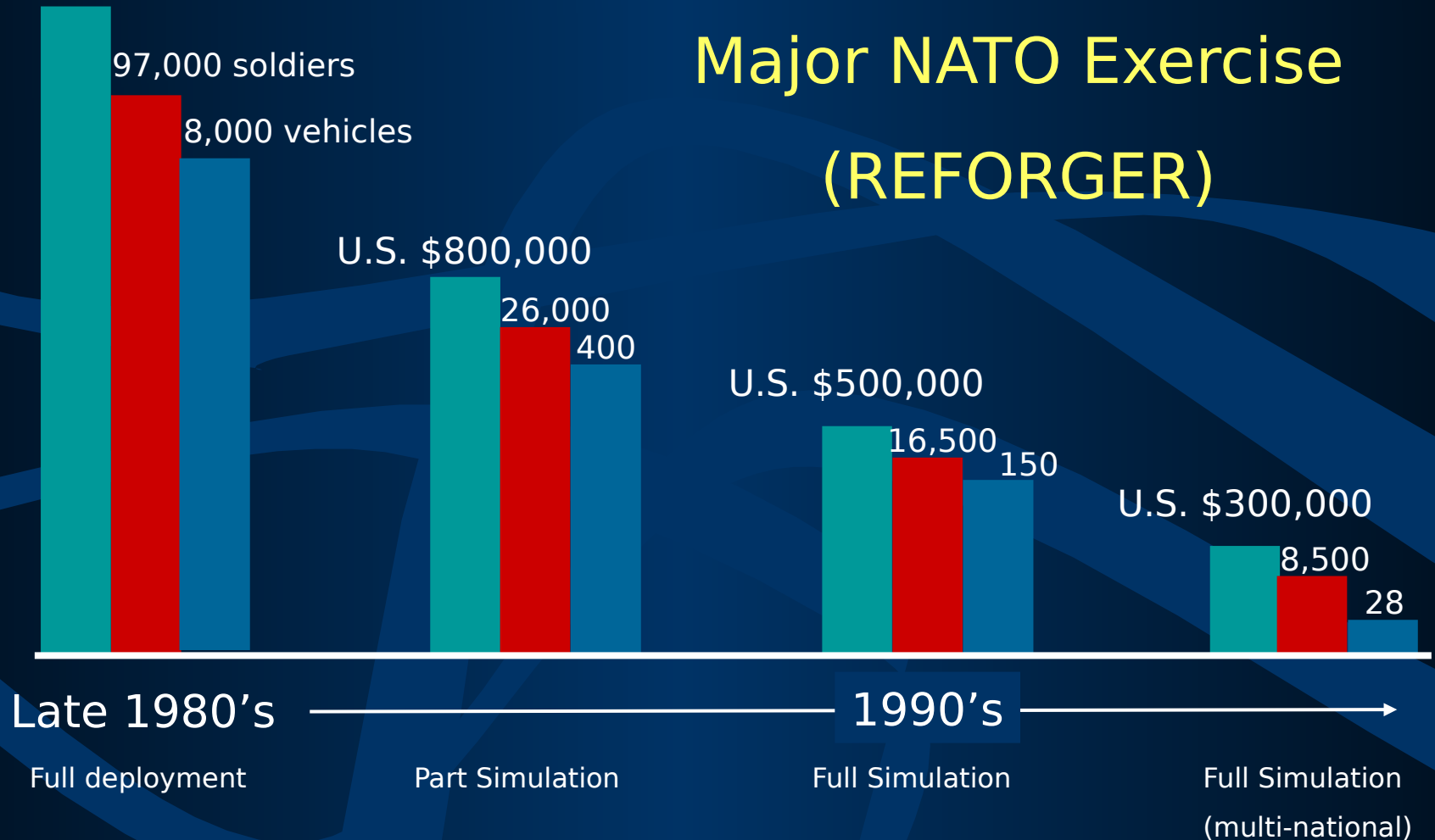
# The M&S User (Buyer) Point of View

- **The user / buyer has considerations:**
  - What do I want / need?
  - What modeling and simulation tools are available?
  - Where and how do I shop for models and simulations?
- **... and cost / value concerns:**
  - What are my criteria for selecting the right models and simulations?
  - Am I willing to pay more for quality, convenience, and security?
  - What will it cost and what will be the return on my investment?
  - How do I determine if I should build my own model or simulation or buy an existing one?

# Cost Savings Example

U.S. \$1,600,000 (per unit trained)

## Major NATO Exercise (REFORGER)





# • Overview

## PART I

- Overview
- Common Definitions
- DoD Framework
  - Structure
  - Functional Areas
  - Programs

## PART II

- M&S Master Plan
- Interoperability
- Representation
- Common Services
- Sharing the Benefits

# What is Modeling and Simulation?

**An attempt to  
imitate real world  
processes or  
facilities**



“When humans need to go  
where humans cannot go.”



**Source: Ms. Priscilla Elfrey, NASA Liaison to Nat'l Sim Ctr  
ITEC 2000 presentation**

# Messages From The Top



“The path for this is outlined in Joint Vision 2010... blueprint for future military operations, which *combines modern technology* with *new operational concepts* and *organizational structures* designed to make the most of *technological advances*.”

William S. Cohen

Former Secretary of Defense

1998 Annual Report to the President and the Congress.



# Messages From The Top



*“Simulations must be **interconnected globally**--creating a near-real-time **interactive simulation super highway** between our forces in every theater. Each CINC must be able to tap into this **global network** and connect forces **worldwide** that would be available for theater operations.”*

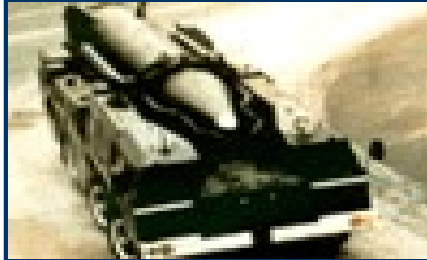
GEN Henry H. Shelton  
Chairman, Joint Chiefs of Staff  
Joint Vision 2010

# 21st Century Military Challenges

Major Theater Warfare



Weapons Proliferation



Information Security



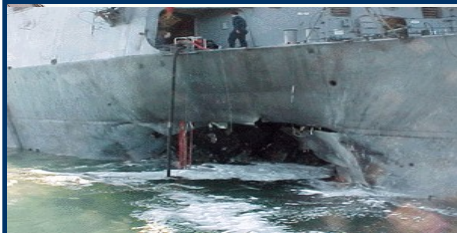
MOOTW



International Drug Trade



Terrorism



Weapons of Mass Destruction



# DoD Mission Environment



***Dwindling  
Resources***



***Increased  
Requirements***



***National Military  
Strategy***



**FORCE STRUCTURE - READINESS - SUSTAINABILITY - MODERNIZATION**

# Forging Tomorrow's Force

## JV 2010:

- **Joint** Capabilities
- **Seams** Between Service Core Competencies
- **Breakthrough** Warfighting Concepts

Land

Sea



Air

Special  
Ops

*Past*

Focus on the *seams*

Land

Sea



Air

Special  
Ops

Develop the  
*breakthrough*  
concepts

"greater than  
the power of 4"

*Future*

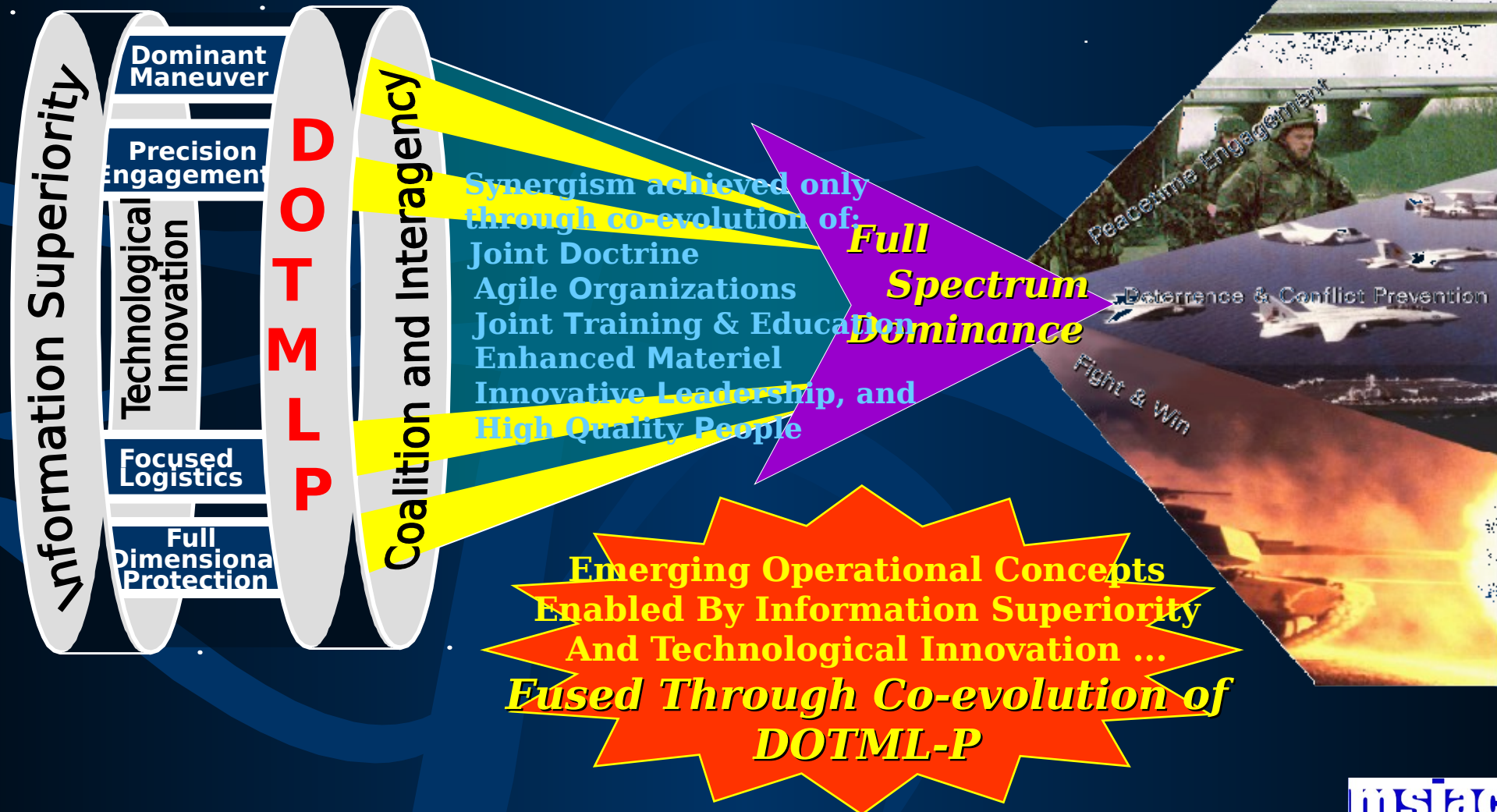
## JV 2020:

*"To build the most effective force for 2020, we must be fully joint: intellectually, operationally, organizationally, doctrinally, and technically."*



# Joint Vision 2010

*M&S supports each aspect of future force evolution*



# Joint Vision 2020

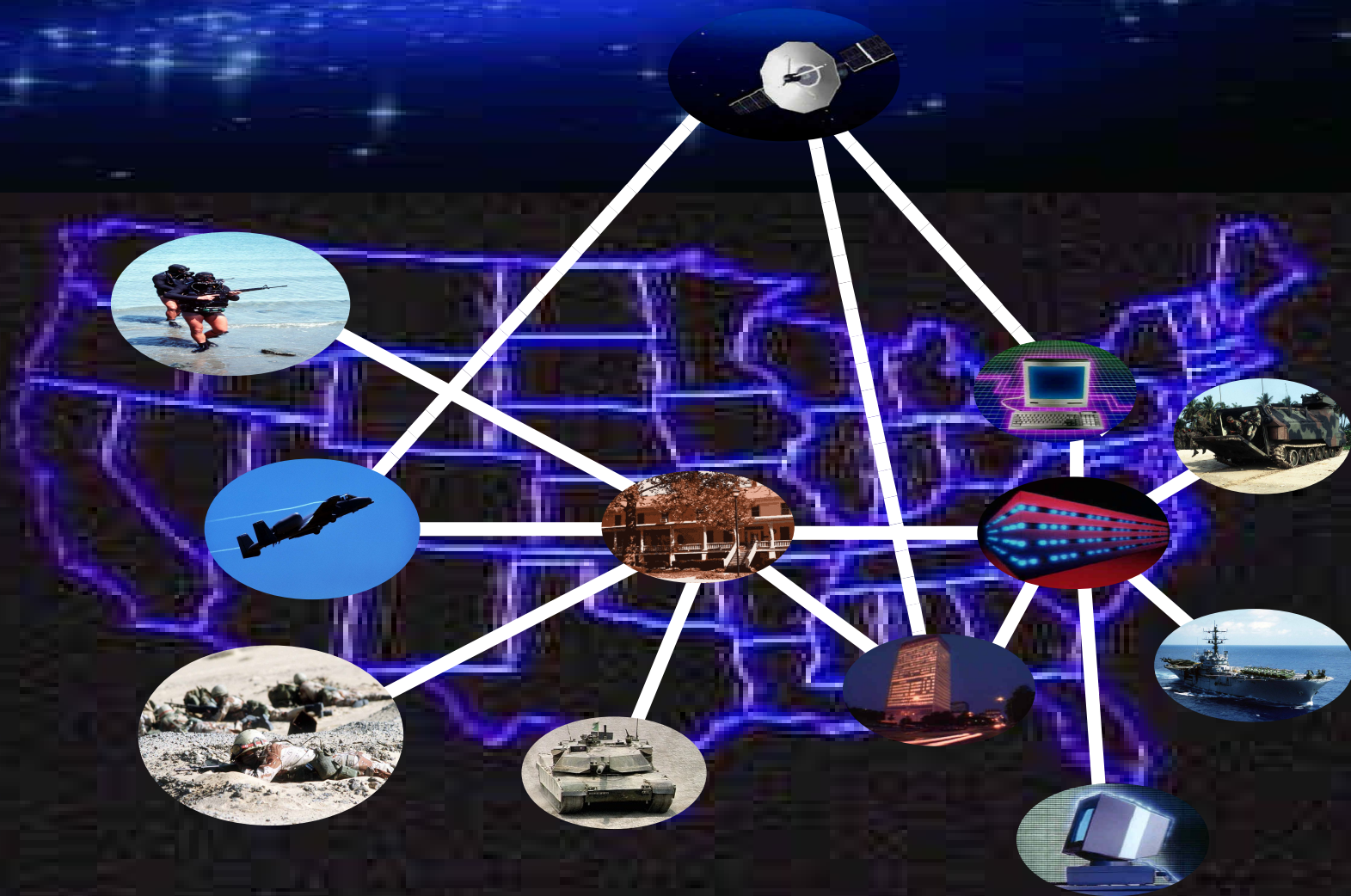
Synergy achieved only through co-evolution of:

***M&S still supports future force evolution***





# Move “trons”, not troops





# Importance of M&S

## Continuing limitations on resources

- competition for resources limits field exercises
- need to carefully examine every investment

## More demanding operational requirements

- new complex missions
- complexity of systems and plans
- demand for joint/combined training
- security challenges

## Greater technical capability at lower cost

- communications
- computers
- advanced software technology

M&S  
offers a  
cost-effective  
solution

**“Modeling and Simulation does not work in isolation.**

**Other technologies and non technology factors are closely integrated and act in conjunction with one another.”**

**Marco Iansiti, Harvard Business School, 1998**

**Creates a  
New  
Language**

**Causes  
Organizational  
Change**

**Causes Organizations  
to Refocus  
their Scope**

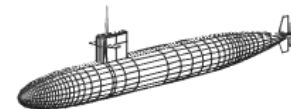
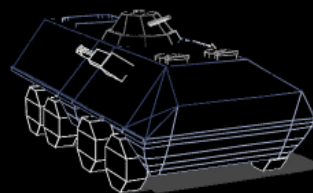
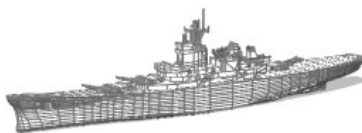
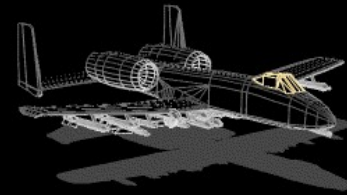
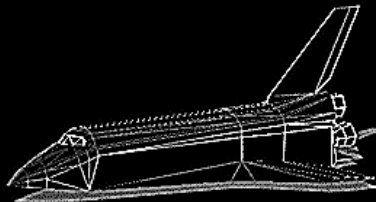
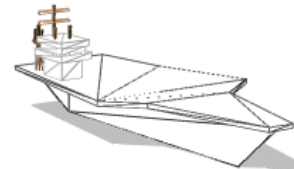
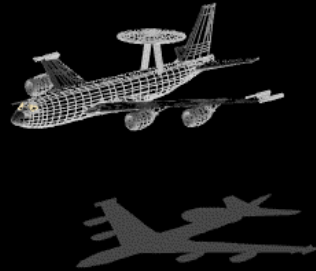
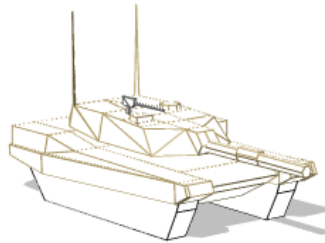


# **Creating a New Language**

# Definition of a Model

**Model** - “A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.”

DoD M&S GLOSSARY, Jan 98



# Types of Models

**“A mathematical model is a symbolic model whose properties are expressed in mathematical symbols and relationships.”**

**DoD M&S GLOSSARY, Jan 98**

**A mathematical model representation is comprised of procedures (algorithms) and mathematical equations.**



# Types of Models

## Example of a Mathematical Model



### CHAPARRAL MISSILE CHARACTERISTICS

Type	Supersonic, surface-to-air
Diameter	2.75 inches
Length	58 inches
Guidance	Passive infrared homing and modified proportional navigation
Range	Excess of 4 kilometers
Speed	Mach 2.2
Warhead	High explosive
Motor	Rocket, solid propellant, two-stage
Acceleration Rate	1 Meter per .5 second

*A = Acceleration Rate*  
*S = Speed of projectile*  
*W = Warhead blast Radius*  
*E = Effective Range*  
*S2 = Target Speed*  
*D = Distance of Target*

$$R = A + \frac{D}{(D/S + D/S2)}$$

$R = \text{Probability of a hit}$

# Types of Models

A **physical model** is a model whose physical characteristics resemble the physical characteristics of the system being modeled.

DoD M&S GLOSSARY, Jan 98

**Physical models** are the symbolic forms utilized for simulators.

# Types of Models

## Example of a Physical



# Types of Models

**A Process Model** models the processes performed by a system.

DoD M&S GLOSSARY, Jan 98

**Process Models** allow for the expression of dynamic relationships of a situation expressed by mathematical and logical processes.

# Types of Models

## Example of a Process Model

Target ID

Call for Fire

FDC

Fire Mission  
to Gun

Fire

Steel on  
Target



Scan for  
Target  
ID Friend  
or Foe

Call Fire  
Mission  
to FDC

Clear  
Fires,  
Compute

Send FM  
to Gun

Gun  
Crew  
Tasks

Target  
Destroyed

$T_1$

$T_2$

$T_3$

$T_4$

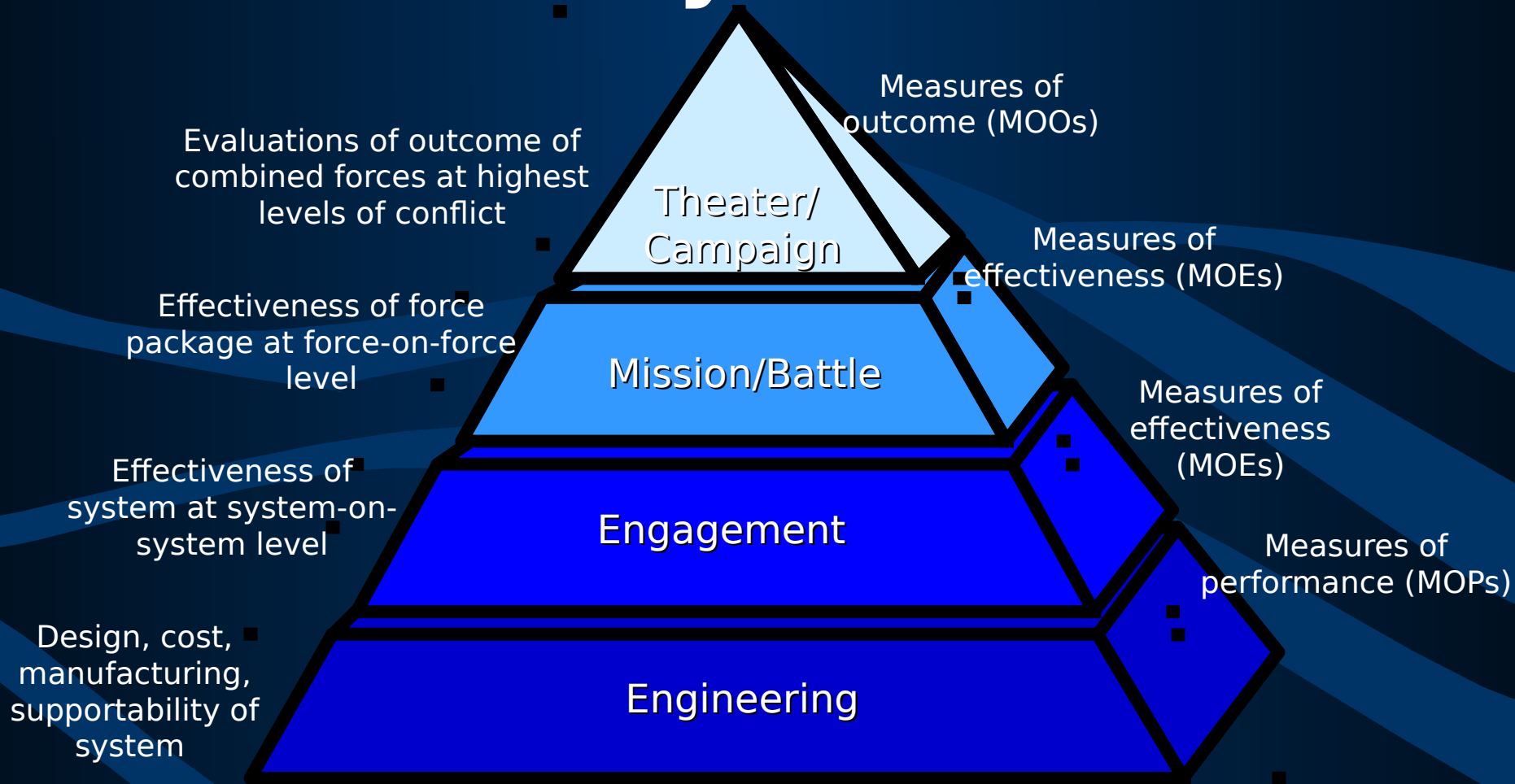
$T_5$

$T_6$

(For  $T = \text{Time}$ )  $T_1 + T_2 + T_3 + T_4 + T_5 + T_6$  Time on Target



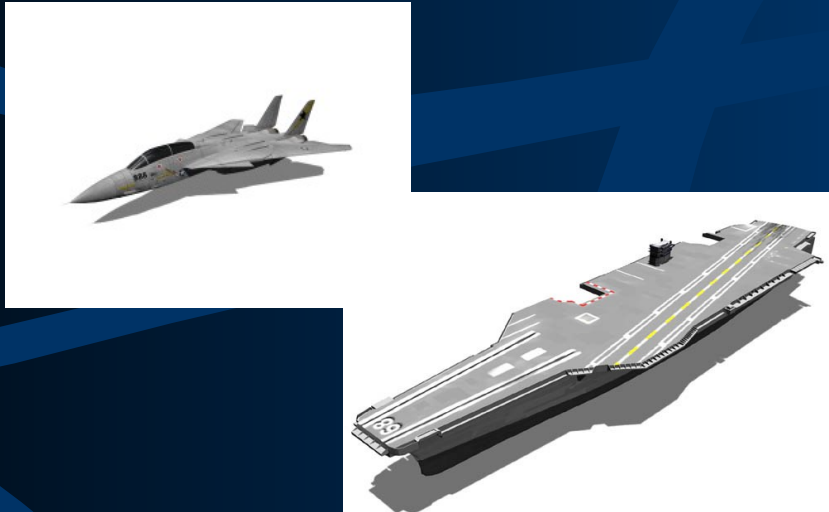
# Hierarchy of Models



**SBA: A New Approach, 1997-1998,  
DSMC Military Research Fellows**

# What is a Simulation?

***Simulation*** - A method for implementing a model over time. DoD M&S GLOSSARY, Jan 98



- Live
- Virtual
- Constructive

# Types of Simulation

**Live Simulation** - A simulation involving real people operating real systems.

DoD

M&S GLOSSARY, Jan 98

## **Live simulations:**

- involve individuals or groups
- may use actual equipment
- may provide a similar area of operations
- may not fully replicate actual activity

# Types of Simulation

## *Example of a Live Simulation*



### ***May Result in :***

- ***Large Resource Expenditure***
- ***Safety Hazards***
- ***Maneuver Damage***

# Types of Simulation

***Virtual Simulation*** - A simulation involving people operating simulated systems.

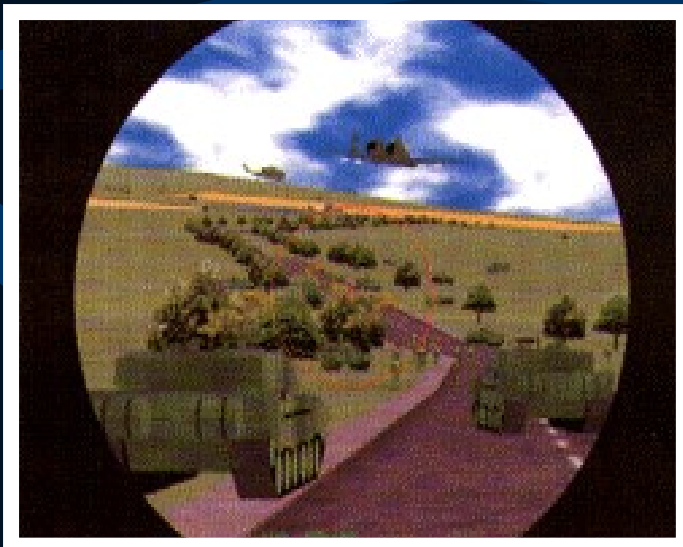
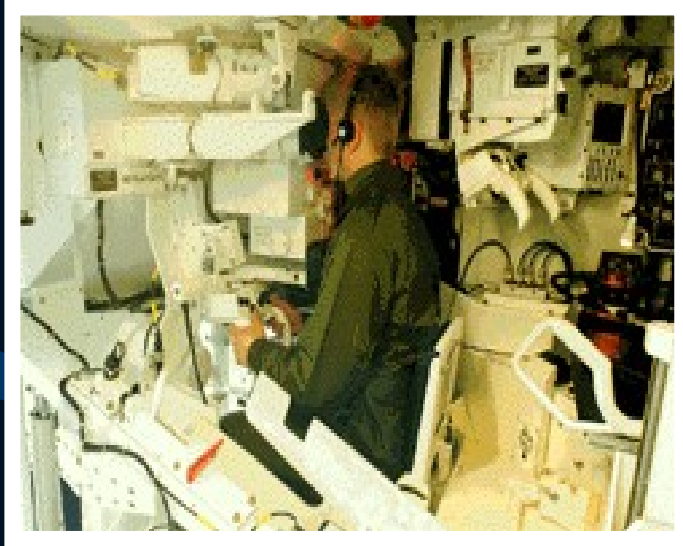
Virtual simulations involve human activity in a central role by exercising:

- motor control skills (flying an airplane)
- decision skills (when to fire, when to move)
- communication skills (practicing proper commands to a tank crew)



# Types of Simulation

## *Examples of Virtual Simulation*



# Types of Simulation

***Constructive Simulation*** - Simulations that involve simulated people operating simulated systems. Real people stimulate (make inputs) to such simulations, but are not involved in determining the outcomes.

**DoD M&S GLOSSARY, Jan 98**

# Types of Simulation

## Example of a Constructive Simulation



### Constructive simulations:

- make measurements
- generate statistics

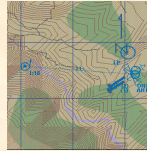
### Constructive simulations offer the ability to:

- analyze concepts
- predict possible outcomes
- stress large

- Many constructive simulations use a large number of established **legacy models**.
- Most provide a valuable service, but **may not** be designed to **share information**.

# Distributed Simulation (DS)

Connected simulations, sharing information through state-of-the-art communication systems.



Constructive



Live



Virtual



Virtual



Live



Constructive

**Can be across  
the world or  
across  
the room!**

# Concept of Polygons

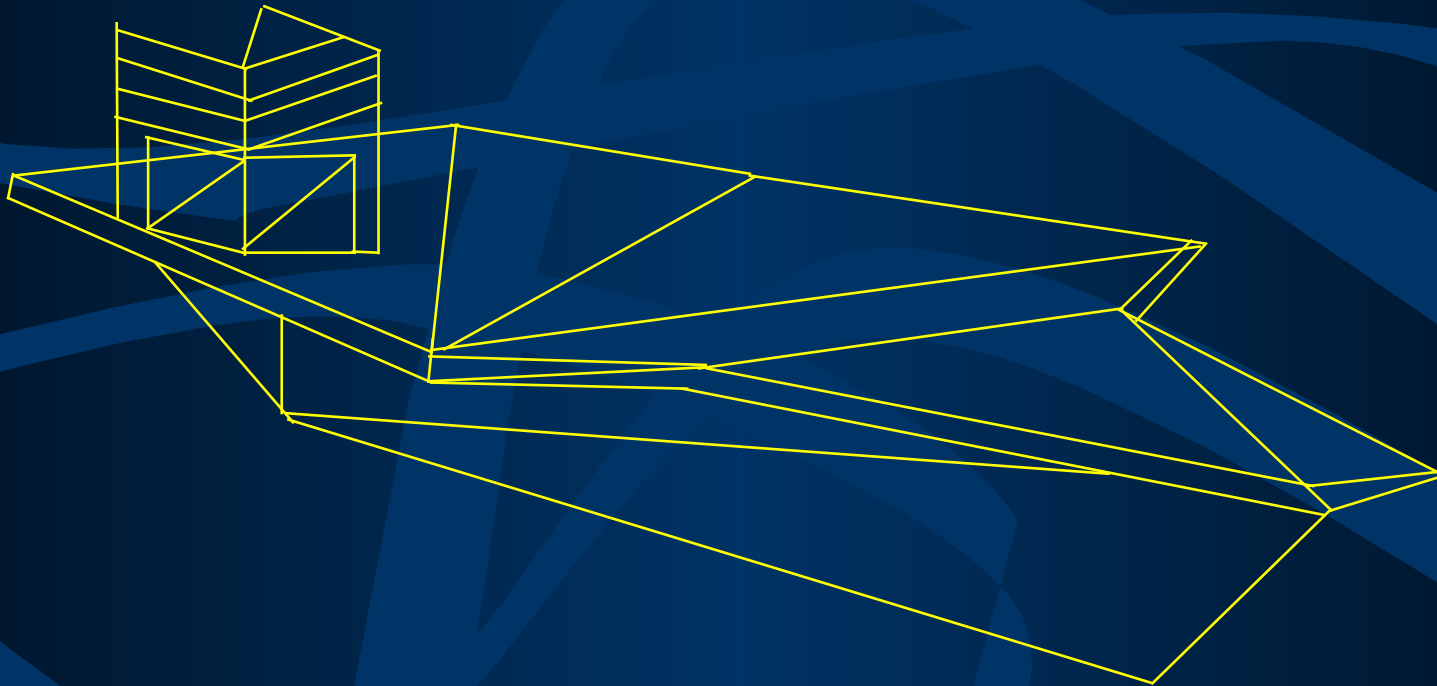
A ***polygon*** is a flat plane figure with multiple sides, the basic building block of virtual worlds. The more polygons a computer can display and manipulate per second, the **more realistic** the virtual world will appear. Humans perceive the equivalent of 80 million polygons at more than 30 frames per second in normal vision.

DoD M&S GLOSSARY, Jan 98



# Concept of Polygons

*A closed plane figure bounded by  
straight lines*



**Trade off -- How much is good enough?  
> detail = > cost**

# Pixels

A **PIXEL** is a "picture element," that refers to the smallest visual unit in an image on a computer display.

DoD M&S GLOSSARY, Jan 98



Any of the small discrete elements that together constitute an image (as on a television screen)

# Fidelity

***Fidelity*** : The accuracy of the representation when compared to the real world.

**DoD M&S GLOSSARY, Jan 98**



**Vs**



**A model or simulation is said to have fidelity if it accurately corresponds to or represents the item or experience it was created to emulate.**

**How does it act?**

# Resolution

**Resolution** : The degree of detail and precision used in the representation of real world aspects in a model or simulation.

DoD M&S GLOSSARY, Jan 98



**Vs**



**Resolution means the fineness of detail that can be represented or distinguished in an image.**

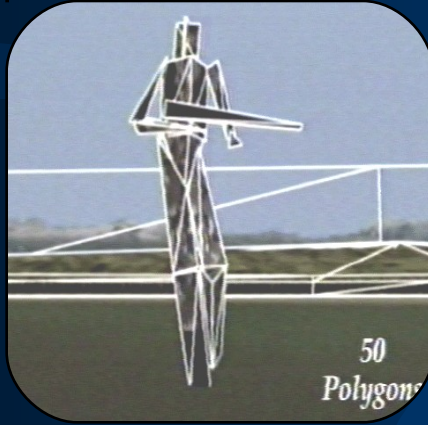
**How does it look?**

# Resolution





# Resolution vs. Fidelity



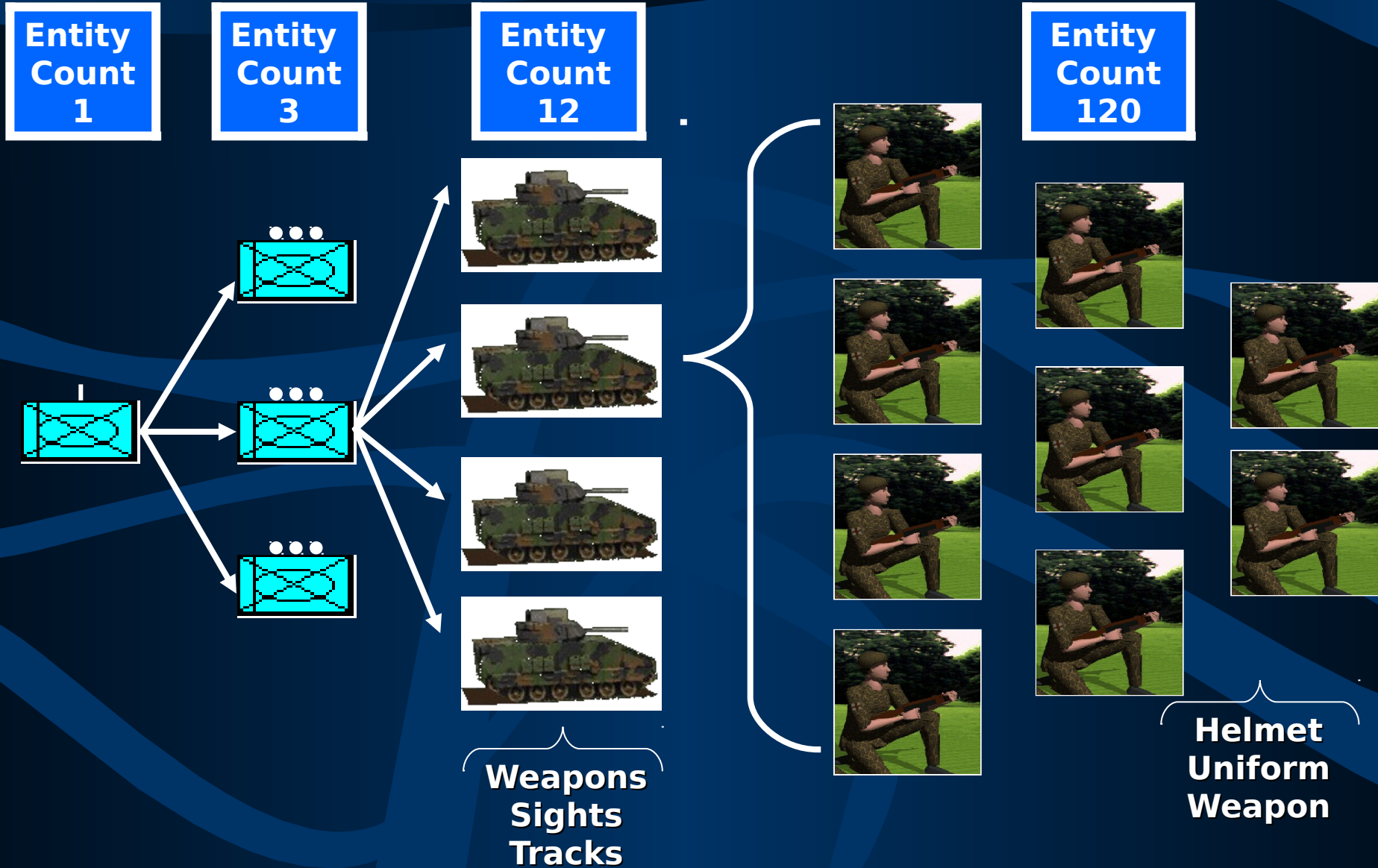
**Fidelity**

**Resolution**



- Resolution and Fidelity are not the same
- You can have one and not the other
- Not necessarily a bad thing
- It depends on what you are trying to accomplish

# Aggregation and Disaggregation



# Dependency in Representation

High Fidelity +



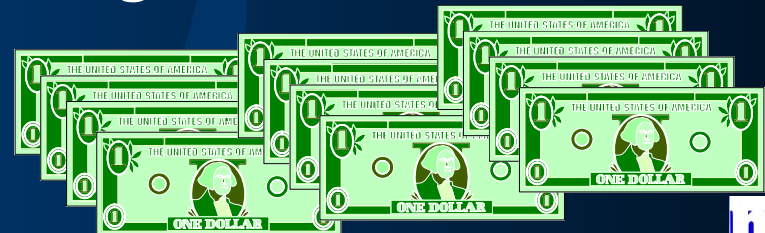
High Resolution



Disaggregation =



High Resource Costs



# How Much is Enough?

The answer depends on the problem:



Problem: Train basic skills

M&S Requirements: Low fidelity, low resolution, unclassified data, etc.



Problem: Mission rehearsal

M&S Requirements: High fidelity, high resolution, classified data, etc.



# **Causes Organizational Changes**



- **DoD Framework**
  - Structure
  - Functional Areas
  - Programs

## PART I

- Overview
- Common Definitions
- DoD Framework
  - Structure
  - Functional Areas
  - Programs

## PART II

- IS&S Master Plan
- Interoperability
- Representation
- Common Services
- Sharing the Benefits

# Factors that Effect the Use of M&S in DoD



# **“America’s First Battles” By Charles Heller and William Stofft**

## **Long Island 1776**

**1000+ killed, wounded or captured**

## **Buna Nov 1942-Jan 1943**

**2848 killed, wounded or missing**

## **Queenston Heights 1812**

**300 killed or wounded, 900 captured**

## **Kasserine Pass Jan-Feb 1943**

**6,300+ killed, wounded or captured**

## **Bull Run 1861**

**1584 killed or wounded, 1312 missing**

## **Task Force Smith July 1950**

**1,150 killed, wounded or captured  
and loss of all equipment**

## **San Juan Hill and El Caney 1898**

**1520 killed or wounded**

## **Cantigny May 1918**

**941 killed or wounded**

## **Ia Drang Valley, Oct-Nov 1965**

**256 killed and 295 wounded**

**How can we train the warfighting leadership to  
experience the “first battle” prior to combat?**

***A Solution - Through  
Simulation***

# Initially, M&S was Strictly a Service Function



***The direction and focus of M&S was not always clear!***





# Defense Science Board

## Mission of the Defense Board:



Advise the  
Secretary  
of  
Defense



Through the  
Under Secretary of Defense  
for  
AT&L



On Scientific  
And  
Technical Matters



As they affect the perceived needs of the Department of Defense

- Thirty-two members and seven ex officio members
- Members selected on the basis of their preeminence in:
  - Science
  - Technology and its application to military
  - Operations
  - Research
  - Engineering
  - Manufacturing and Acquisition process



# Objectives

## **Management**

- Establish a DoD-Wide Structure to Coordinate Joint M&S Activities and Requirements
- Fix Responsibilities to Ensure Proper M&S Oversight

## **Planning**

- Develop a Master Plan
- Furnish Guidance for the Consistent Development of Component M&S Plans

## **Policy**

- Implement a DoD M&S Policy Focusing on Interoperability and Standards; Verification, Validation, and Accreditation;
- Development of Common Tools and Methodologies;
- Service Responsibility for M&S of its Forces

## **Coordination**

- Promote Coordination Across Programs and Functional Communities
- Establish Means to Facilitate Information Sharing across the M&S Community

## **Investment**

- Implement a Long-Range M&S Investment Strategy
- Promote Initiatives to fill Critical Technology Gaps

# DoD Mission for Modeling and Simulation

## **Mission**

**To strengthen the use of modeling and simulation in joint education, training and military operations; research and development; test and evaluation; analysis; and production and logistics.**

**DepSecDef Memorandum, "Modeling and Simulation Management Plan," 1991**

# DoD M&S Vision

Provide **readily-available, operationally-valid** environments to: **(i.e., credible)**

- train jointly, develop doctrine and tactics, formulate operational plans, and assess war fighting situations
- support technology assessment, system upgrade, prototype and full scale development, and force structuring

DepSecDef Memorandum, "Modeling and Simulation Management Plan," 1991

# DoD M&S Vision (cont.)

***Common use*** of environments that promotes closer interaction between operations and acquisition communities

- allow maximum utility and flexibility
- by constructing M&S environments from ***affordable, reusable, interoperable components*** through an open system architecture

*Vision revalidated by EXCIMS, Spring 99*

DepSecDef Memorandum, "Modeling and Simulation Management Plan," 1991

# Organization

**Under Secretary of Defense (Acquisition, Technology, and Logistics)**

**Director  
Defense Research and  
Engineering  
(DDR&E)**

**Executive Council for Modeling and  
Simulation**

*O-8/SES reps from across DoD*

**Training  
Council**

**Analysis  
Council**

**Acquisition  
Council**

**Defense Modeling and Simulation Office  
(DMSO)**

**Modeling and Simulation Working Group  
(MSWG)  
*O-6/GS15 reps from across DoD***

**M&S  
Executive Agents**

**Architecture  
Management Group**

**Task Forces**

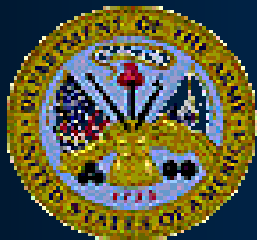
**Technical  
Work Groups**

**Functional  
Work Groups:  
Training, Analysis,  
Acquisition**



# Modeling and Simulation Offices

## AMSO



**Mr. W. H. "Dell" Lunceford, Jr.**  
<http://www.army.amso.mil>  
(703) 601-0010

## AF-XOC



**Dr. Jacqueline Henningsen**  
<http://204.34.204.77>  
(703) 695-1833

## Joint Staff



**J-8**  
**Mr. Vincent P. Roske, Jr.**  
<http://www.dtic.mil/jcs/>  
(703) 697-8853

## NAVMSM



**CAPT Richard Bump**  
<http://navmsmo.hq.navy.mil>  
(703) 601-1482

## MCMSMO



**Dr. Michael Bailey**  
<http://www.mcmsmo.usmc.mil>  
(703) 784-9570

# DMSO Staff



**Chief of Staff**  
Gary Yerace



**Director**  
COL Wm. Forrest Crain USA

**Deputy Director**  
TBD

**Chief, Warfighter  
Requirements Division**  
LtCol Chris  
Hadinger USMC



**Chief, Concepts  
Application Division**  
Lt Col Eileen  
Bjorkman USAF



**Chief, Business & Financial  
Management Division**  
Waverly Debraux

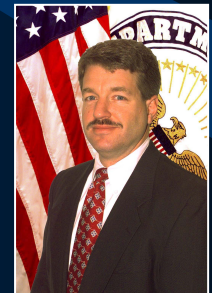
**Chief, Policy,  
Plans & Integration  
Division**  
David Cantrell



**Chief, Enterprise  
Division**  
Fred Hartman

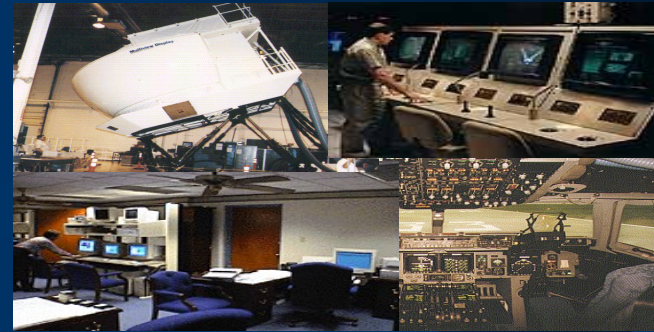


**Chief, S&T  
Initiatives Division**  
Dr. Phil Barry



# M&S Functional Areas

## Training



## Analysis

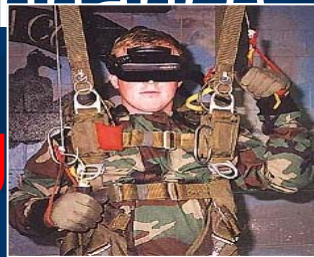


## Acquisition

# The Role of Modeling and Simulation

M&S is being used worldwide by the military, industry, and academia as a technological enabler to enhance:

- training



- analysis



- acquisition





# Modeling and Simulation in Training

**Modeling and Simulation can provide a realistic and sometimes cheaper, way to train.**



- **Ammunition, fuel, repair parts are expensive.**
- **M&S provides a method for training individuals and units in a safe environment, without expending precious resources.**

# Modeling and Simulation in Training

## Reasons to use M&S in training:

- prepare commanders
- train staffs
- rehearse plans
- plan for contingencies
- practice new processes and tactics
- refine standard procedures
- exercise new equipment and technologies





# Modeling and Simulation in Analysis

## **Military analysts use M&S to:**

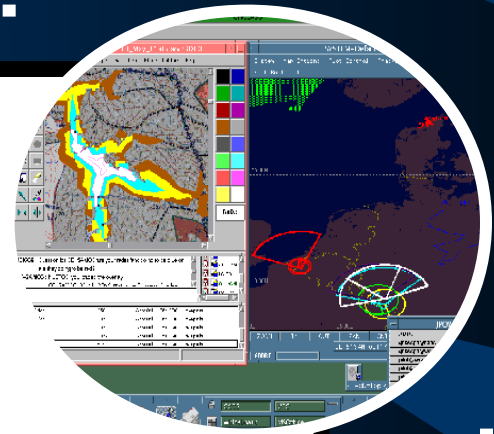
- help shape the size, composition, and structure of forces, and
- meet national military strategies and to assess operational plans.



# Modeling and Simulation in Analysis

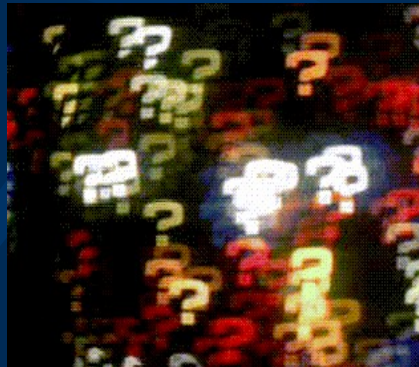
## *Analytical Simulations*

- *Operations support:*
  - Decision-making support for:
    - \* current operations
    - \* future (tactical and strategic) operations
    - \* logistics and administration
- *Assessment:*
  - Two types:
    - \* force capability and requirements
    - \* combat developments



# What M&S Adds to Analysis

- A *tool* to assist in decision making
- A way to *focus* on problems
- A way to quickly *test* potential solutions
- A method to *identify constraints* (e.g., logistics, operational, environmental)



# Acquisition Functional Area



Dr. Jacques S. Gansler  
USD (AT&L) Former  
DMSO Industry Day  
6 Jun 1998

“We are committed to *reforming the acquisition system* and recognize that an *essential tool* for accomplishing that reform will be *modeling and simulation.*”

Research  
and  
Development



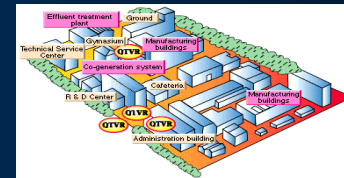
Super Hornet  
First Flight Test

Testing  
and  
Evaluation



FAA Crash Analysis

Production  
and  
Logistics



Virtual Factory

# Modeling and Simulation in Acquisition

## The military acquisition community uses M&S to:

- test requirements for new equipment
- conduct research and analysis
- develop prototypes (avoid building costly, full scale models)
- plan for efficient production and sustainment





# M&S Functional Areas

Analysis

Training

Acquisition

***Some excellent M&S out there, but they***

- are not linked
- meet localized needs only
- do not exchange any sort of data
- comprise hundreds of models and simulations, making it difficult to know what's available



# Joint M&S Programs

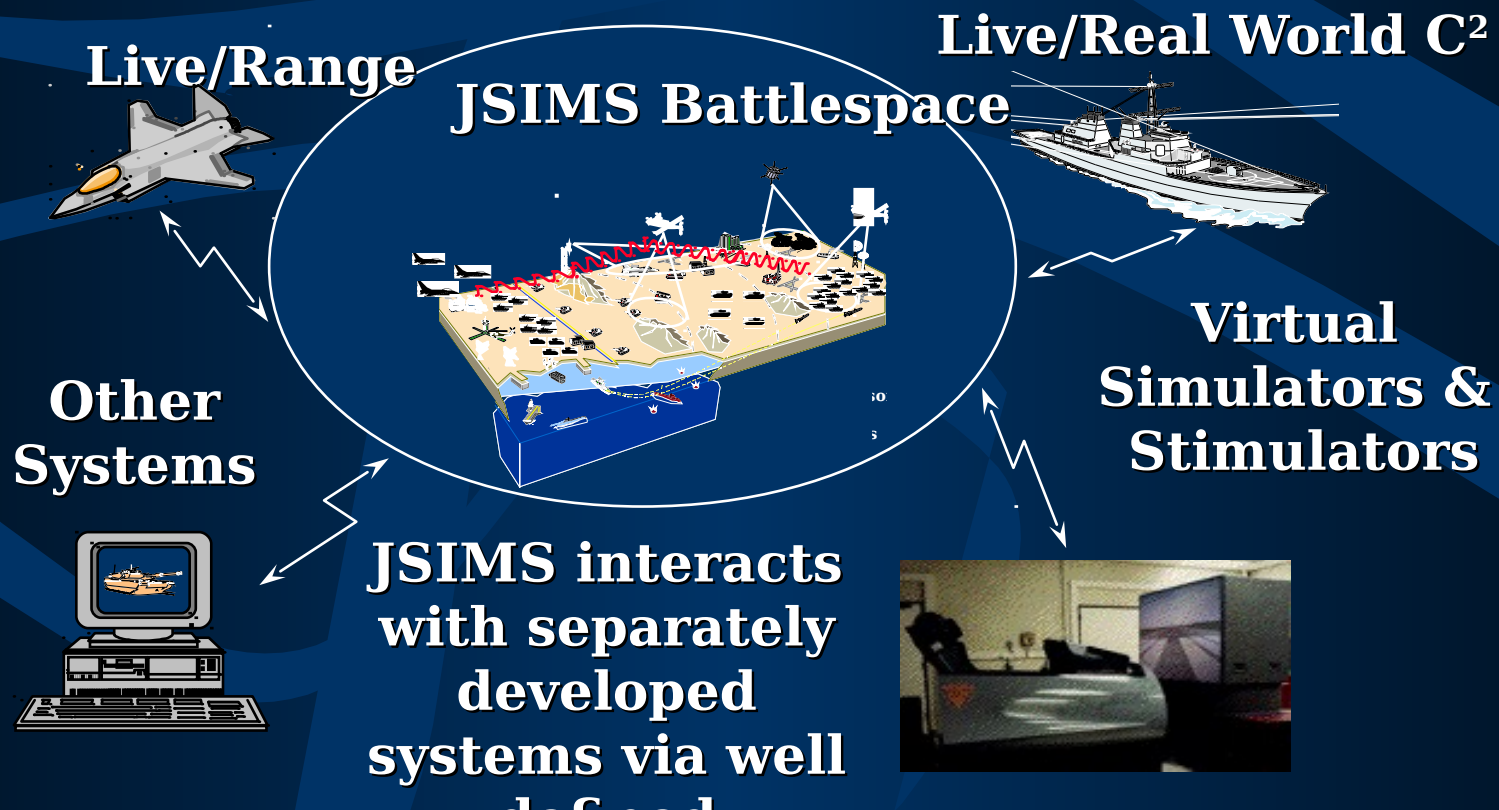


# Joint Simulation System (JSIMS)

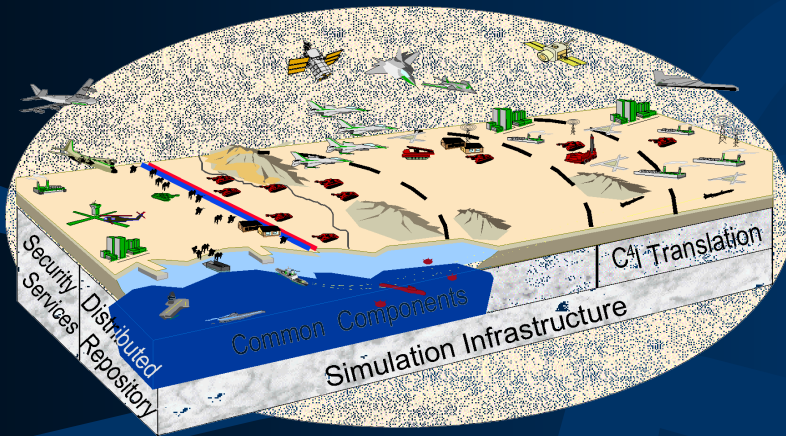
<http://www.jsims.mil>



- Single, distributed, seamlessly integrated constant simulation environment.
- Supports Joint or Service training, rehearsal, and education objectives.



# What is JSIMS ?

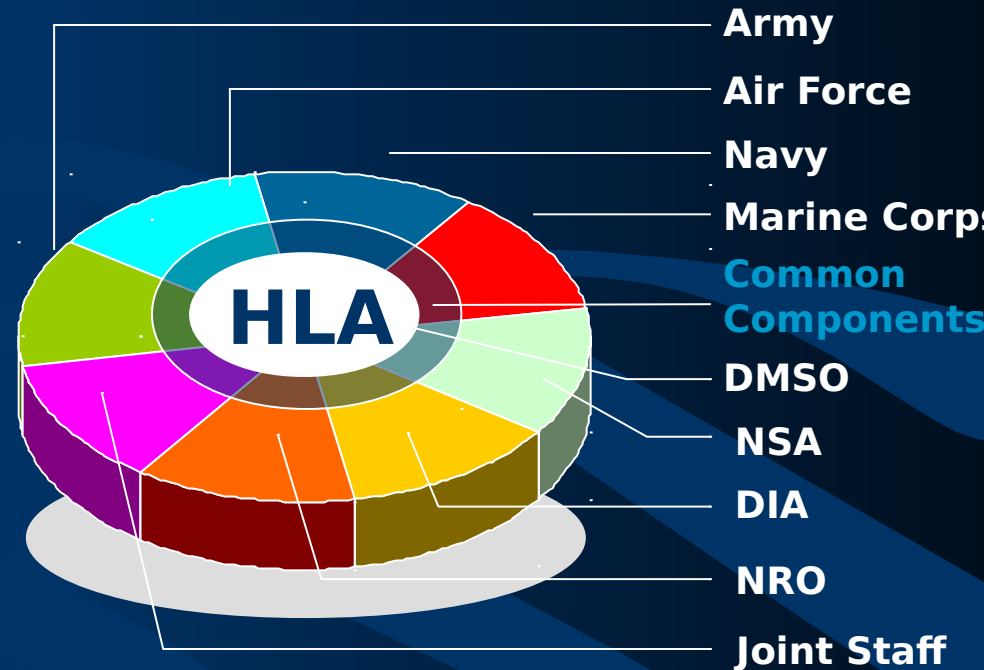


A Joint, interoperable simulation

**DoD's "flagship" modeling and simulation program for the warfighters**

- Replace outdated Service legacy systems
- Real-world C4I systems ... using common components
- Distributed training ... mission planning ... mission rehearsal

Source: "The JSIMS Presentation", DMSO Industry Days 2000



A collaborative effort of nine partner simulations

# Joint Warfare System (JWARS)

<http://www.dtic.mil/jwars>



- Constructive simulation of joint theater warfare
- Aids in force assessment; deliberate and crisis action planning; system effectiveness; concept and doctrine development / assessment

## PAYOFF

FORCE STRUCTURE



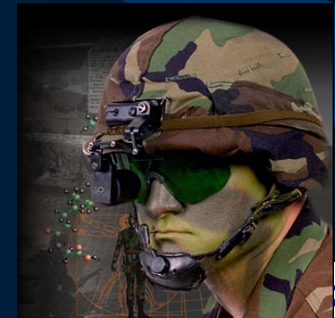
READINESS



SUSTAINABILITY



MODERNIZATION



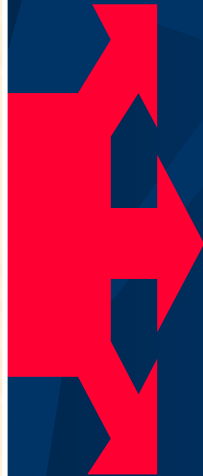
# Mission

**Develop a state-of-the-art, constructive simulation that will:**

- **Provide a multi-sided and balanced representation of joint theater warfare**
- **Assess current and future operational concepts: ie: Dominant Maneuver, Precision Engagement, Focused Logistics, and Full-Dimension Protection**
- **Use C4 and ISR as the foundation for how entities perceive and interact with one another**

## **Users**

- **Joint Staff**
- **Services**
- **CINCs**
- **OSD**
- **Joint Task Forces**
- **Other DoD org's**



## **Applications**

- 1. Force assessment**
- 2. Planning and execution**
  - **Deliberate planning**
  - **Crisis action planning**
- 3. System effectiveness and trade off analysis**
- 4. Concept and doctrine development and assessment**

**Source: JWARS Presentation  
DMSO Industry Days 2000**



# Joint Modeling and Simulation System (JMASS)

<http://www.jmass.wpafb.af.mil>

- JMASS is a simulation support environment.
- Collection of well-defined, well-documented interface standards to which a model should be built.
- Includes a tool kit which allows modelers to build representations of real world systems, configure those models, assemble them into simulations, execute those simulations and process the results.



## **JMASS GOALS:**

- Standard, consistent, engagement-level M&S tool
- Reduce model development costs
- Improve interoperability
- Analysis focused on results, not the tools
- Scientific and technical foundation for higher-level M&S



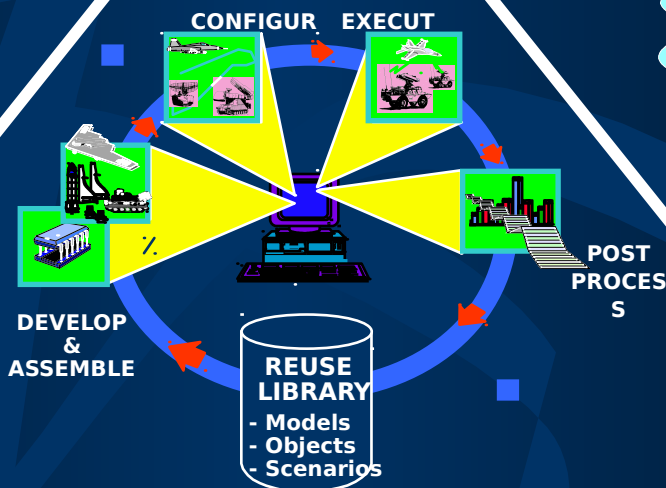
# Four Parts of JMASS

## Legacy Model Function Implementation

- Fuzing
- Endgame ( $P_k$ ) calculations
- Pilot Mental Model
- Missile Flyout

**Red Threat Models**

**Blue Digital System Models**



**JMASS Architecture**  
(Tools, services, standards and interfaces)

**Tri-Service Program**

**Source: JMASS Presentation, DMSO Industry Days 2000**

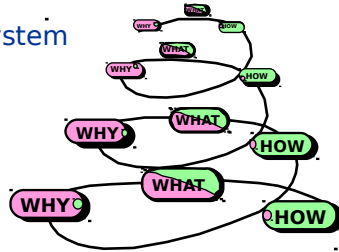
# Simulation Based Acquisition (SBA)

<http://www.msiac.dmsso.mil/sba>

## Iterative Acquisition Process

- Iterative Spiral Process
- Electronic exchange of System Models
- Rapid Evaluation of Multiple Options

### Process



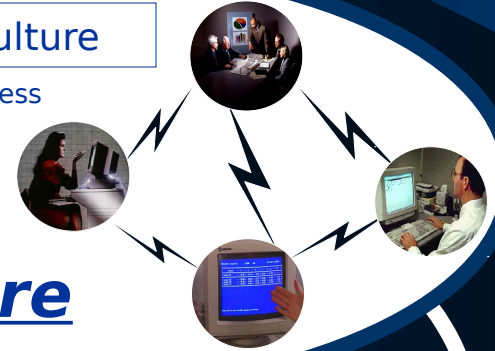
Government Industry

*SBA - Not just M&S support, but a new engineering environment, process, & culture*

## Evolved Acquisition Culture

- Enabled Integrated Process Teams
- Changing Roles and Responsibilities

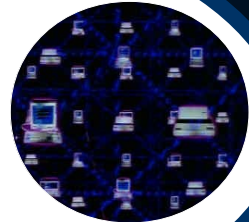
### Culture



## Integrated Advanced Engineering and Management Enterprise

- Collaborative Distributed Engineering
- Info Repository
- Integrated Design Data Schema

### Environment



# • M&S Master Plan

## PART I

- Overview
- Common Definitions
- DoD Framework
  - Structure
  - Functional Areas
  - Programs

## II

- M&S Master Plan
- Interoperability
- Representation
- Common Services
- Sharing the Benefits

# Prior to 1990s

**Focus was on  
two areas of  
the world!**



# What we thought would be the result of losing one focus area!





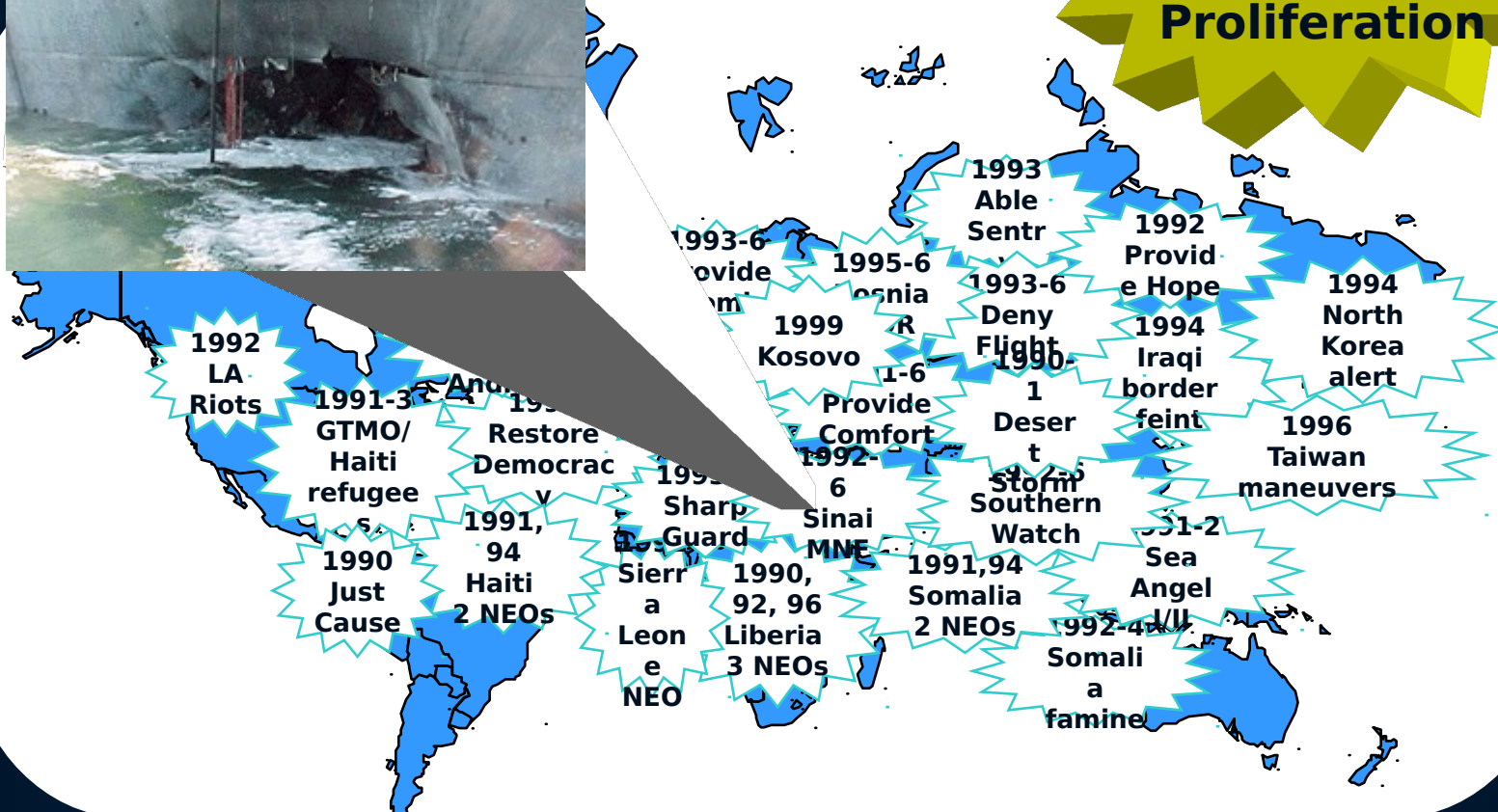
# Reality of Today: Less \$, Multi-Threats

\$\$\$\$\$\$\$\$\$

USS  
COLE



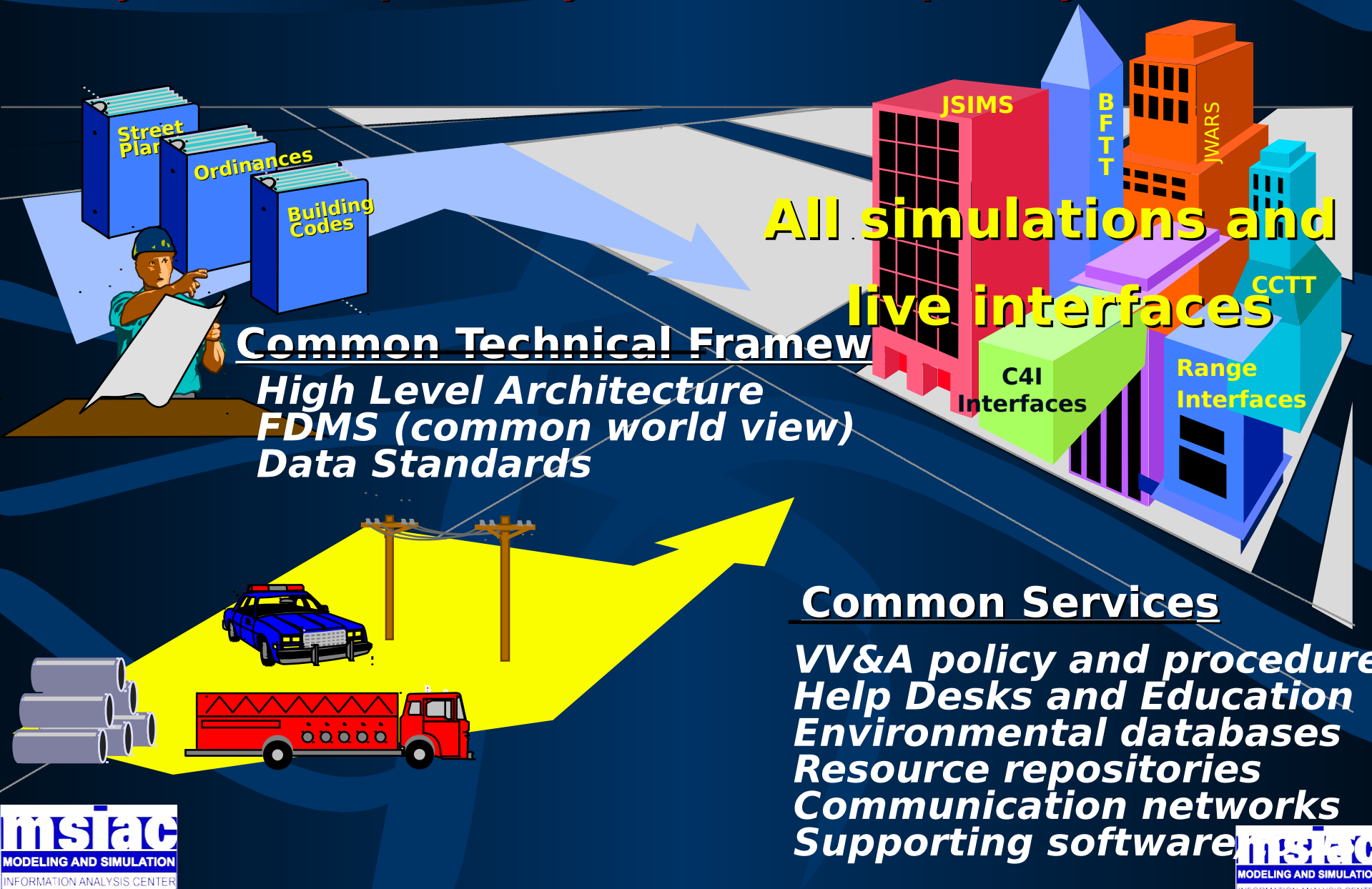
**2010**  
**Chem/Bio**  
**Anti-**  
**Terrorism**  
**Counter**  
**Proliferation**





# M&S: An Analogy to City Planning

**Payoffs: Interoperability and reuse = capability and cost-effectiveness**



# Modeling and Simulation Master Plan (MSMP)

**The MSMP is a DoD plan developed under USD(AT&L) authority and coordinated through DoD Components**

## **The MSMP establishes:**

**Short-term  
Goals and Objectives  
(Present to 6 Years)**

**Long-term  
Goals and Objectives  
(Beyond 6 Years)**

## **The MSMP provides:**

**A Road Map That  
Delineates  
the Management,  
Investment,  
And Technical  
Strategies**

**Joint and  
Common Use  
Applications  
of M&S**

**Assessment  
Of  
Current M&S  
Capabilities**

# DoD M&S Master Plan

## Objective 1

**Develop a common technical framework for M&S**

- HLA
- CMMS [FDMS]
- Data Standardization

## Objective 2

**Provide timely and authoritative representations of the natural**

- Atmosphere
- Terrain
- Space
- Oceans

## Objective 3

**Provide authoritative representations of systems**

## Objective 4

**Provide authoritative representations of human behavior**

- Individuals
- Groups and Organizations

## Objective 5

**Establish an M&S infrastructure**

- Field Systems
- VV&A
- Repositories
- Communications
- Coordination Center

## Objective 6

**Share the benefits of M&S**

- Quantify Impact
- Education
- Dual-Use

**DoD 5000.59-P, Modeling and Simulation Master Plan  
October 1995**

# Objective 1

**Interoperability!**

## ***Common Technical Framework:***

- ***High Level Architecture (HLA)***
- ***Functional Description of the Mission Space (FDMS)***
- ***Data Standards***

# Concept of Interoperability

Interoperability is the ability of two simulations to communicate.



A example of interoperability is talking on the telephone, internationally, when both the technology and the language must be compatible.



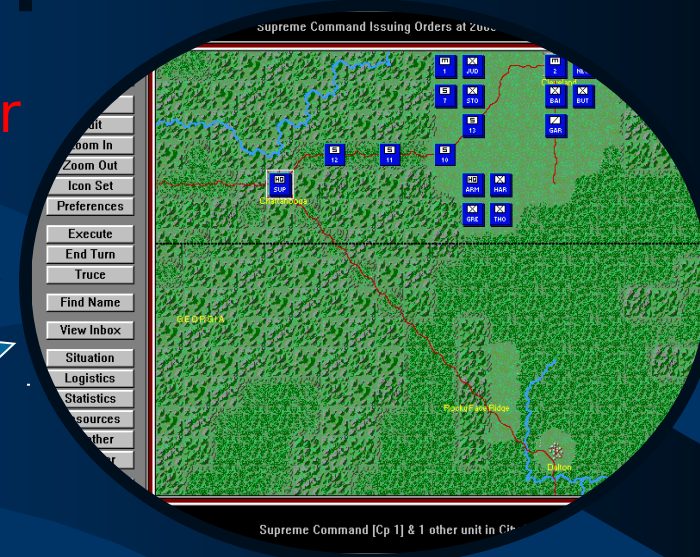
# Concept of Interoperability

Interoperability allows  
different types of  
simulations to work together

Simulation "A"



Simulation "B"

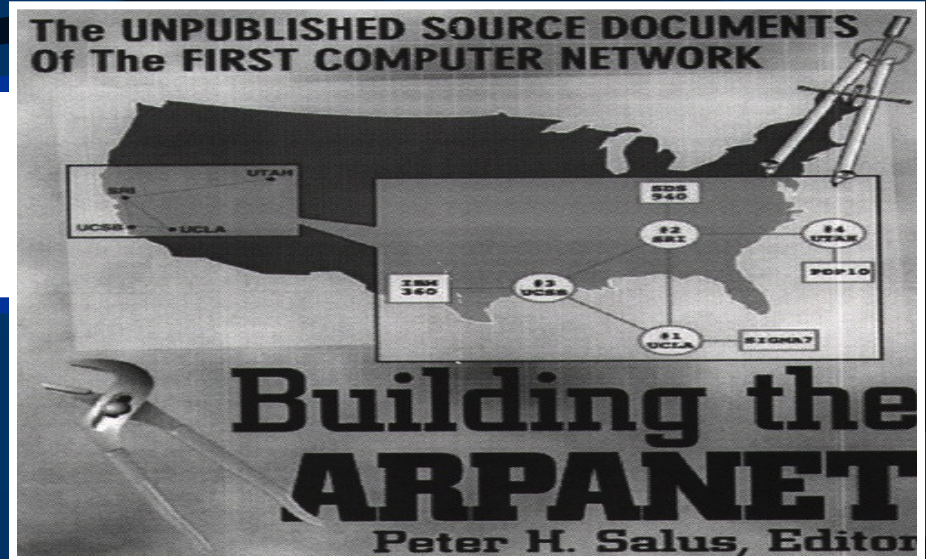


**M&S Interoperability.** The ability of a model or simulation to:

- engage in two-way interaction with other models and simulations
- enable simulations to operate effectively together

# History of Interoperability

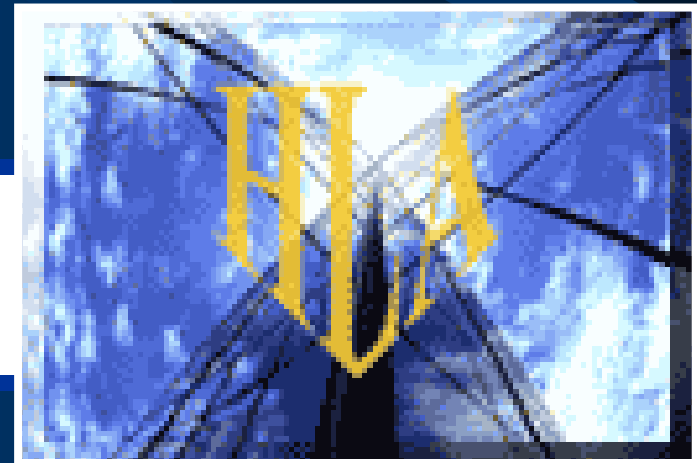
**1971 - ARPANET, first distributed information network**



**1982 - SIMNET, first networked, virtual simulation environment**



**Today - Common Technical Framework (CTF)**



# Distributed Interactive Simulations (DIS)

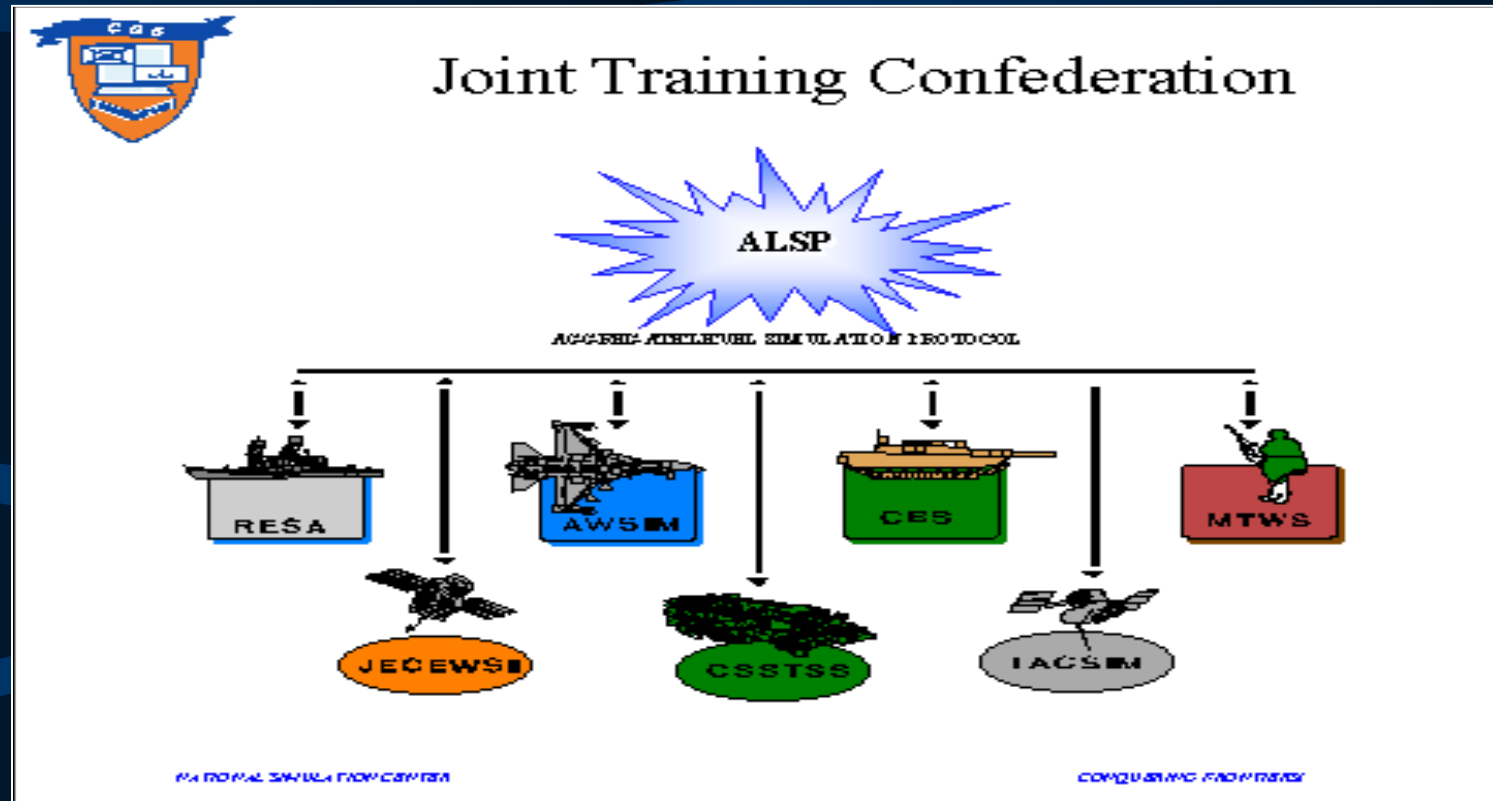
A means of linking simulators and simulations in an interactive environment.

- Transmits information using Protocol Data Units (PDUs). Each PDU contains a header (identification) and body (information).
- Still out there in many DoD legacy simulations and in some allied simulations

## *Issues:*

- Runs in real time only
- Uses full broadcast distribution

# Aggregate Level Simulation Protocol (ALSP)



- Connects family of simulations known as the Joint Training Confederation (JTC)

## *Issues:*

- Only addresses JTC needs

# Interoperability Today - CTF

**KEY: Interoperability and Reusability**

The CTF comprises the “city codes” for M&S in the area of Technical Components and Infrastructure.

High Level Architecture (HLA)

Data Standards

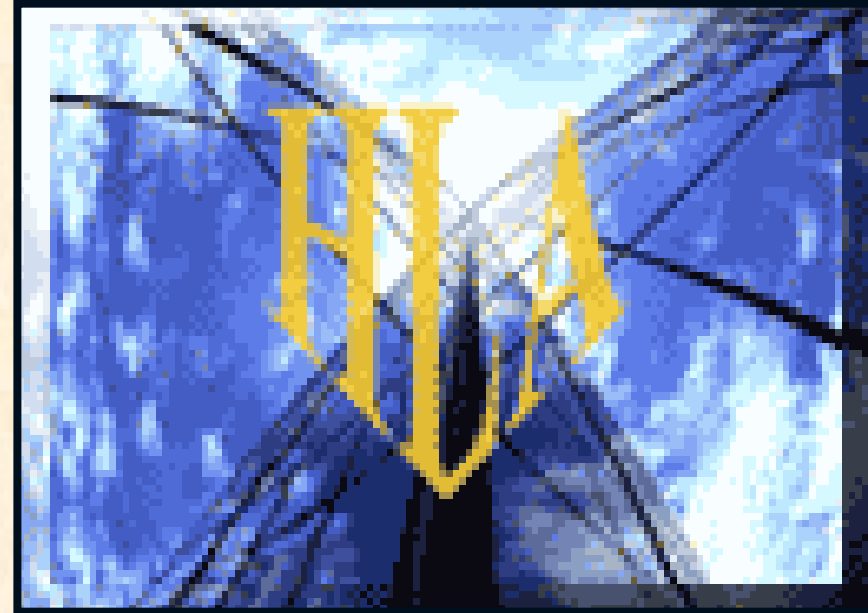
Functional Description of the Mission Space (FDMS)





# High Level Architecture (HLA)

- Supersedes ALSP, DIS
- Mandated by DoD
- Multiple time management schemes
- Selectively passes data
- Can accommodate new and legacy simulations
- Supports broad user community

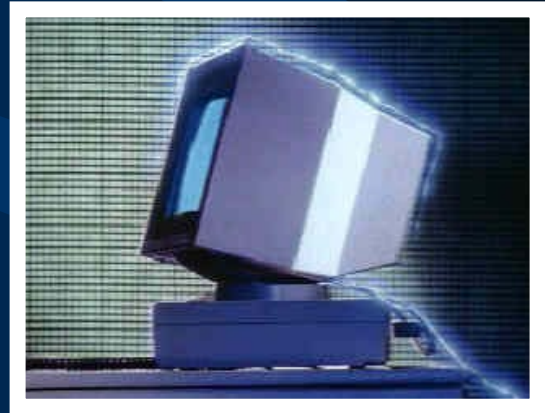
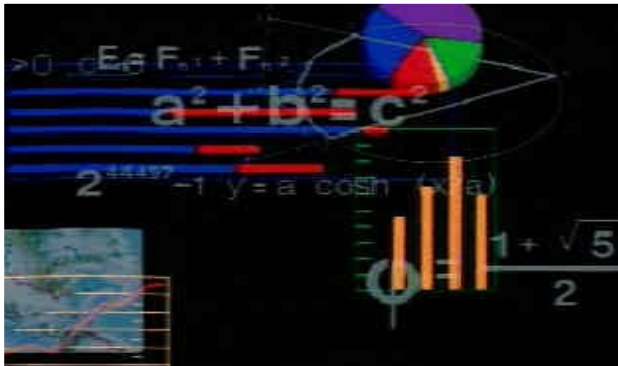


# Interoperability Today - HLA

## *HLA is the Cornerstone of CTF*

In Simulations, “Stuff” Is Represented With Information About Characteristics and Processes.

HLA Allows for the Different Simulations to Exchange Objects and their Attributes



This “Stuff” is Known As “Objects and their Attributes”.

# HLA Definitions

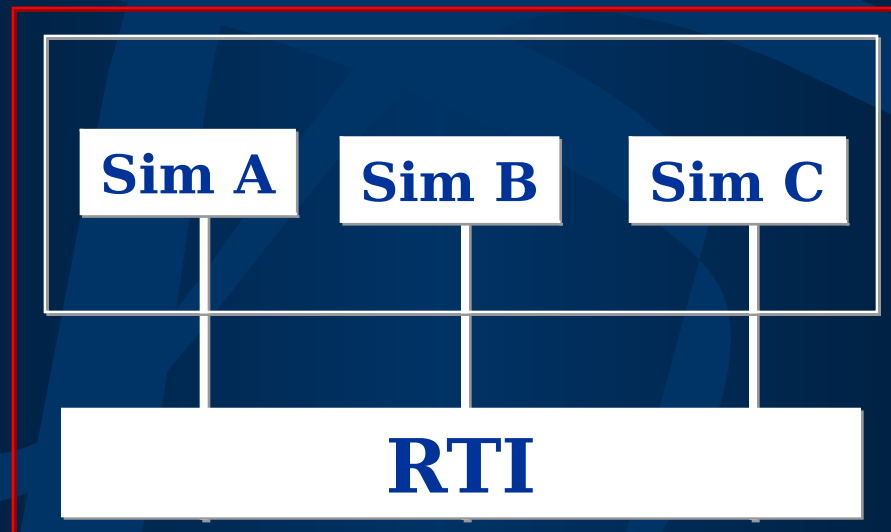
**Federate:** one simulation; could represent:

- one platform (e.g., cockpit)
- aggregate (e.g., air traffic flow)

**Federation:** a set of federates, a common object model and supporting connecting software

**Runtime Infrastructure (RTI):** Provides a set of services which are used by federates to coordinate their operations and data exchange during a runtime execution. RTI is connecting software.

*Federation:*



*Federates*

*Interfaces*

# HLA Elements

## **Rules**

**Designed to achieve interaction. Define relationships among federation components:**

- 5 apply to the federation
- 5 apply to the federate

## **Object Model Template**

**Common framework to specify the form in which simulation elements are described and documented**

## **Interface Specification**

**Software that allows federates to interface through the RTI.**

# HLA User Services

Policy --

Developers --

Services --

The screenshot shows the 'High Level Architecture' website. The left sidebar is yellow and contains a navigation menu with three main sections: 'Policy' (with links to General Information, Policy and Transition Reports, Architecture Management Group, and Related Standards), 'Developers' (with links to HLA Technical Specifications, Runtime Infrastructure, Federation Development Processes, Federation Development Tools, HLA Implementations, and Published Papers), and 'Services' (with links to Software Distribution Center, Education and Training, Tools Bulletin Board, Online HLA Tools, and Compliance Testing). Below the menu is a 'SEARCH HLA' box with a 'SUBMIT >>' button. The main content area has a blue header with the title 'High Level Architecture' and a navigation bar with links: 'Questions/Comments', 'What's New', 'Subscriptions', 'HLA FAQ', and 'RTI FAQ'. The main text area is titled 'High Level Architecture (HLA)' and contains the text: 'a general purpose architecture for simulation reuse and interoperability.' Below this is a section 'New to the site...' with two news items. The first item, dated 11-12 August 1999, mentions the Architecture Management Group (AMG) meeting for AMG32 at DMSO and provides a link for more info. The second item mentions an online tour of the HLA Federation Development and Execution Process, also with a link for more info. On the right side of the main content area, there are three promotional boxes: 'HLA Helpers' with links for 'New User', 'DoD Policy', and 'Developers'; 'HLA Training CD's' with the text 'Free while supplies last.' and a 'click here' link; and a box for 'additional DMSO initiatives' with a link to 'www.dmsol.mil'. At the bottom of the main content area, there is a link to 'Please read our Privacy & Security Notice'.

**DM SO**

Home

**General Information**

- Policy and Transition Reports
- Architecture Management Group
- Related Standards

**HLA Technical Specifications**

- Runtime Infrastructure
- Federation Development Processes
- Federation Development Tools
- HLA Implementations
- Published Papers

**Software Distribution Center**

- Education and Training
- Tools Bulletin Board
- Online HLA Tools
- Compliance Testing

SEARCH HLA

SUBMIT >>

## High Level Architecture

Questions/Comments • What's New • Subscriptions • HLA FAQ • RTI FAQ

### High Level Architecture (HLA)

*a general purpose architecture for simulation reuse and interoperability.*

#### New to the site...

**new** On 11-12 August, 1999 the Architecture Management Group (AMG) met for AMG32 at DMSO, download the presentations now.  
[For more info...](#)

**new** Take an online tour of the HLA Federation Development and Execution Process.  
[For more info...](#)

#### HLA Helpers

- ▶ New User
- ▶ DoD Policy
- ▶ Developers

#### HLA Training CD's

Free while supplies last.  
[click here](#)  
4 to Choose

For additional DMSO initiatives visit  
[www.dmsol.mil](http://www.dmsol.mil)

[Please read our Privacy & Security Notice](#)

<http://hla.dmsol.mil>



# Interoperability Today - HLA

***DoD Policy: “Under the authority of [DoD Directive 5000.59], and as prescribed by [the DoD Modeling and Simulation Master Plan], I designate the High Level Architecture as the standard technical architecture for all DoD simulations.”***

***HLA supersedes Distributed Interactive Simulation (DIS) and ALSP***

## **“No Can” Dates**

**-“No Can Pay”- first day of FY99**

**• no funds for developing/modifying non-HLA-compliant simulations**

**-“No Can Play”- first day of FY01**

**• Retirement of non-HLA-compliant simulations**

# HLA Policy Reaffirmation

3 Nov 00 Memorandum of Agreement



**Dr. Jacques Gansler**  
**USD (AT&L) Former**

- **Re-establishes the HLA as the technical architecture for interoperability and reuse.**
  - **All new simulations shall be HLA compliant.**
  - **Upgrades and significant changes (defined by components) shall be HLA compliant.**
  - **Existing non-HLA compliant simulations intended to be interoperable shall be HLA compliant based on Component requirements, resources, and priorities.**
  - **DoD Components shall establish their own policies and processes for transitioning their simulations to HLA or justify exclusion based on requirements, resources, priorities, or security.**
  - **All exclusions shall be documented, justified by the Component, and reported to the EXCIMS**

# HLA and Industry

**HLA is Viewed as Part of Broader Standards**

**Government**

**DoD Joint Technical  
Architecture  
(JTA)**

**(Included, May 98)**

**International**

**North Atlantic  
Treaty  
Organization  
(NATO)**

**(Adopted, Nov 98)**

**Industry**

**Institute of  
Electronic and  
Electrical Engineers  
(IEEE)**

**(Adopted, 21 Sep 2000)**

**Industry**

**Object Management  
Group  
(OMG)**

**(Adopted, Nov 98)**

# Data

# Standards

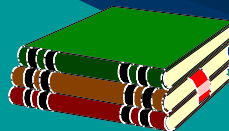
## Knowledge Collection



**P  
E  
D  
I  
G  
R  
E  
E**



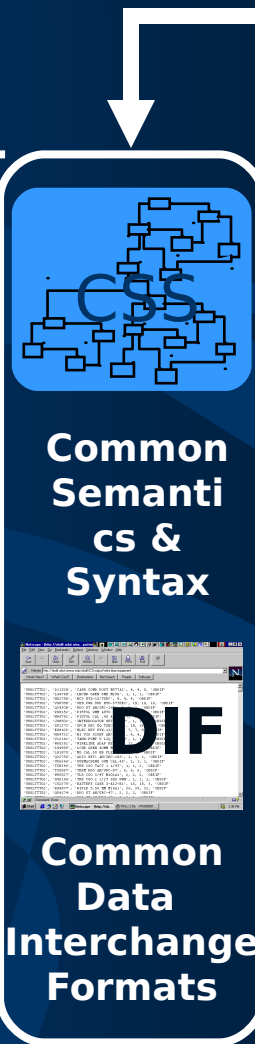
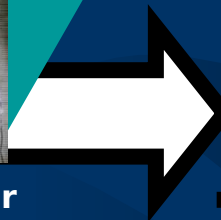
**Component  
Designated Sources**



**Publications  
Doctrine  
Operations  
Tactics**



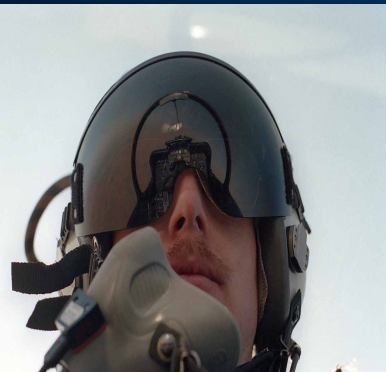
**Subject Matter  
Experts**



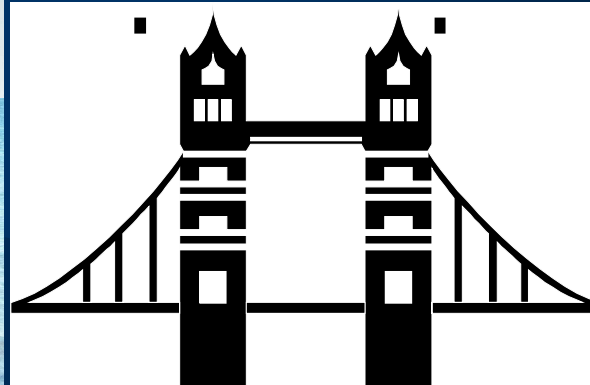


# Functional Description of the Mission Space (FDMS)

**FDMS is a bridge between the warfighter and the developer!**



Front-end analysis to determine warfighter's representation of the real world



**Functional descriptions of relevant aspects of the real (or projected) world, including: entities, processes, and relationships and interactions (including**



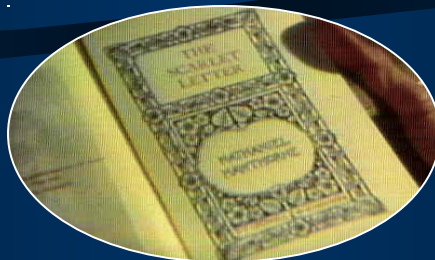
# Objective 2, 3, & 4

**Representation!**

*Natural Environment*  
*Systems*  
*Human Behavior*

# Representation - What's Involved (Baseball Analogy)

*CTF provides*



*the rulebook!*

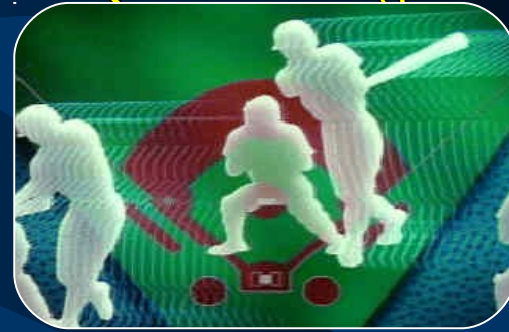
playing Field



Equipment



players



Environment



Systems

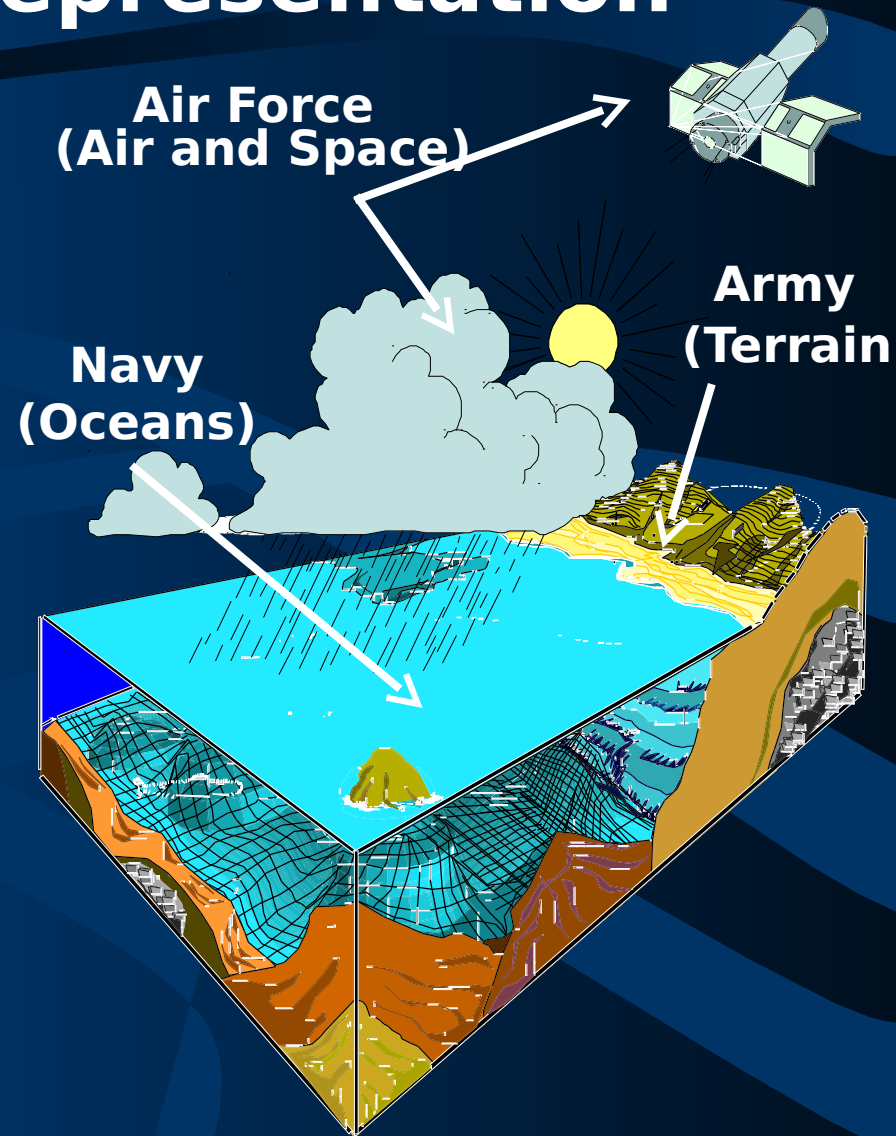


Human Behavior



# Environmental Representation

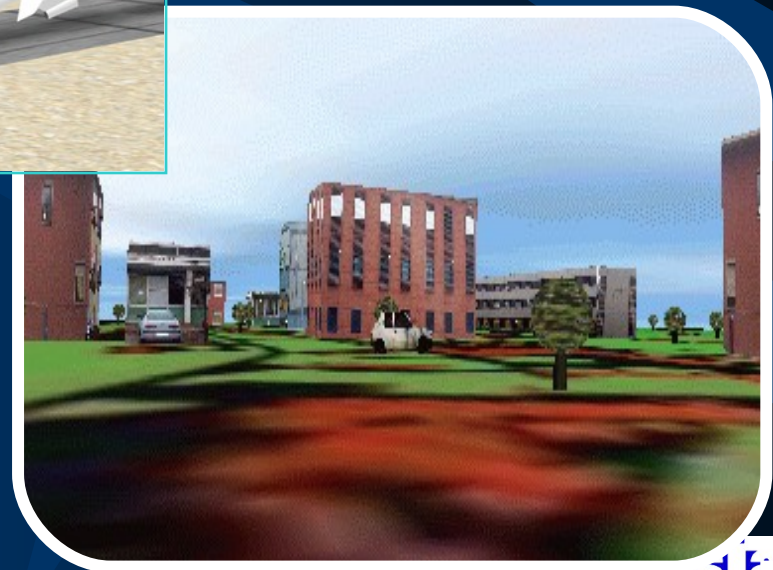
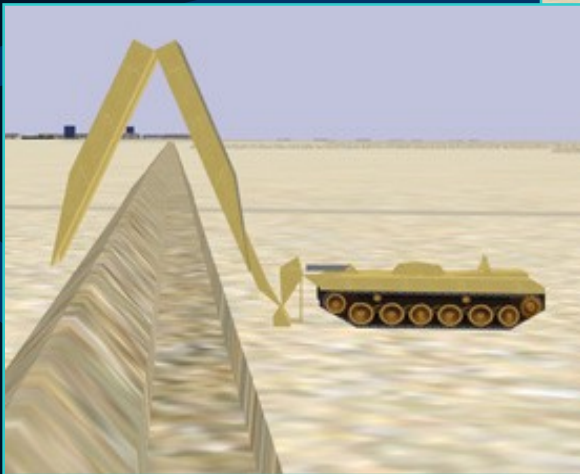
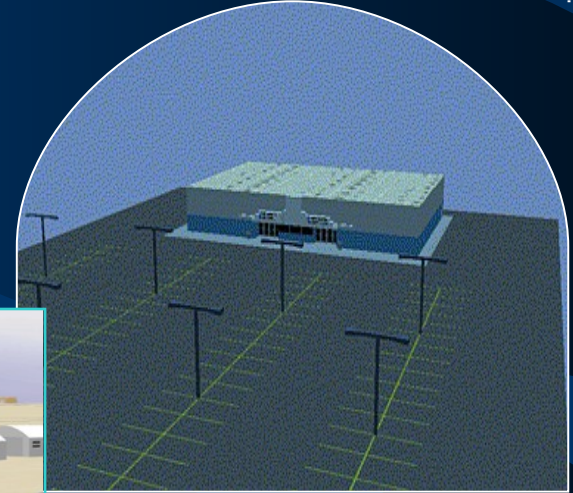
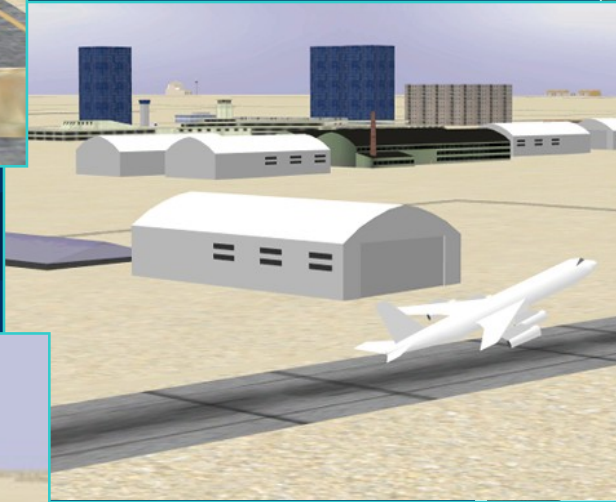
- **Data Collection**
  - Information complexity
  - Level of focus
  - Authoritative source
  - Consistency across categories
- **Boundaries between areas**
  - When does one stop and other start
  - Lack of available information
- **Obtaining agreement across simulations**
  - Specific needs within & between services
  - Level of detail varies across tasks/objectives
  - Bandwidth verses realism
- **Player interference with environment**



**Air and Space:** <http://msea.afccc.af.mil>  
**Oceans:** [www.nrl.navy.mil/OceanEA/index](http://www.nrl.navy.mil/OceanEA/index)  
**Terrain:** [www.tmpo.nima.mil](http://www.tmpo.nima.mil)



# Environment Representation - Examples



# Environmental Executive Agents

## *DoD M&S Executive Agent*

- DoD Component
- USD(AT&L) has assigned responsibility and delegated authority
- development and maintenance of a specific area of M&S application
- relevant standards and databases, used by or common to many models and simulations.

**DoD M&S GLOSSARY, Jan 98**

- Air and Space (USAF): <http://msea.afccc.af.mil>
- Oceans (Oceanographer of the Navy):  
[www.nrl.navy.mil/OceanEA/index.html](http://www.nrl.navy.mil/OceanEA/index.html)
- Terrain (NIMA): [www.tmpo.nima.mil](http://www.tmpo.nima.mil)



# Systems Categorization

## Initial - What type of system or element

Units



Weapons



Platforms



Sensors



Life Support



C4I



## Secondary - Where the system operates

Individual



Ground



Sea

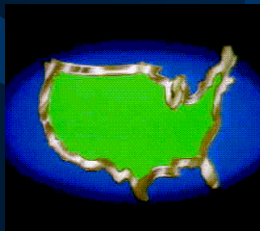


Air



## Final Categorization - Who controls the system

U.S.



Threat



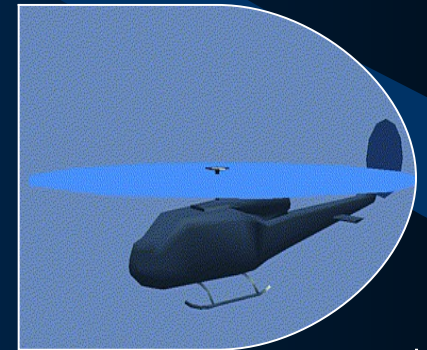
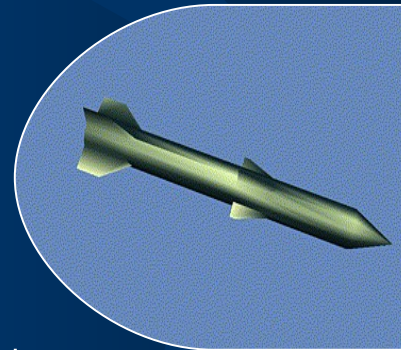
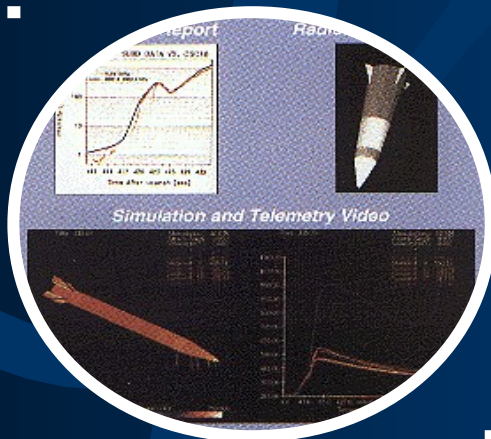
Coalition



# Systems Representation

Systems are represented in both virtual and constructive simulations.

The accuracy of the performance of the system in the simulation is dependant upon the accuracy of the data used to represent the system.





# Human & Organizational Representation

Humans and Organizations are represented in four primary areas w



**Training**



**Systems Analysis**



**Command Decision Aiding**



**System Acquisition**

**Individuals**



**Teams**



**Organizations**

**Sensing & Perception**



**Physical Movement**



**Information Processing**



**Decision Making**

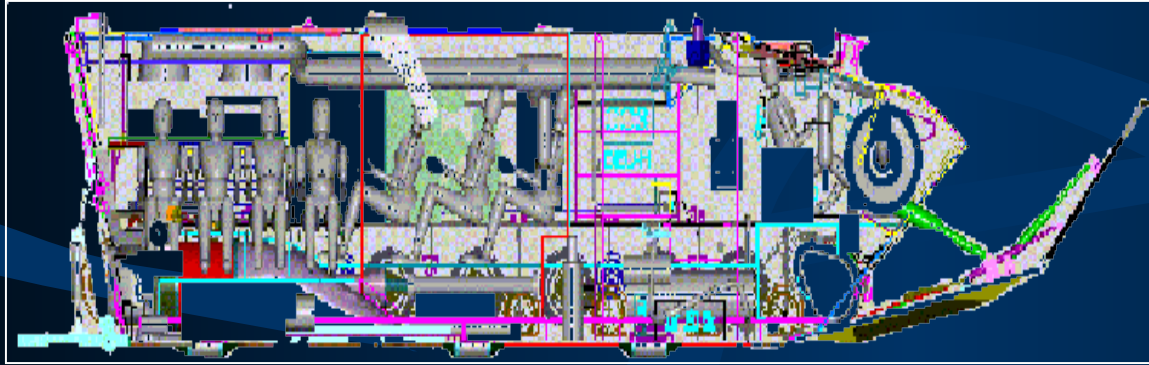


**Communication & Coordination**

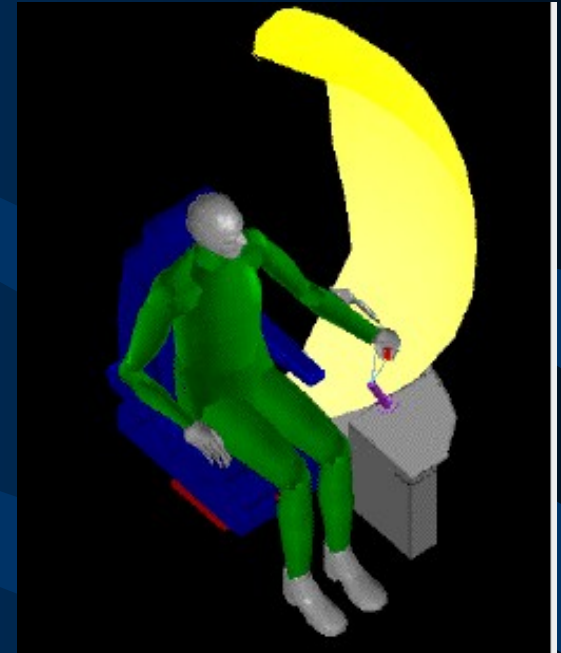


# *Human Behavior Representation Example*

## Research & Development Implications



Accelerates design integration of  
hardware, software and human systems

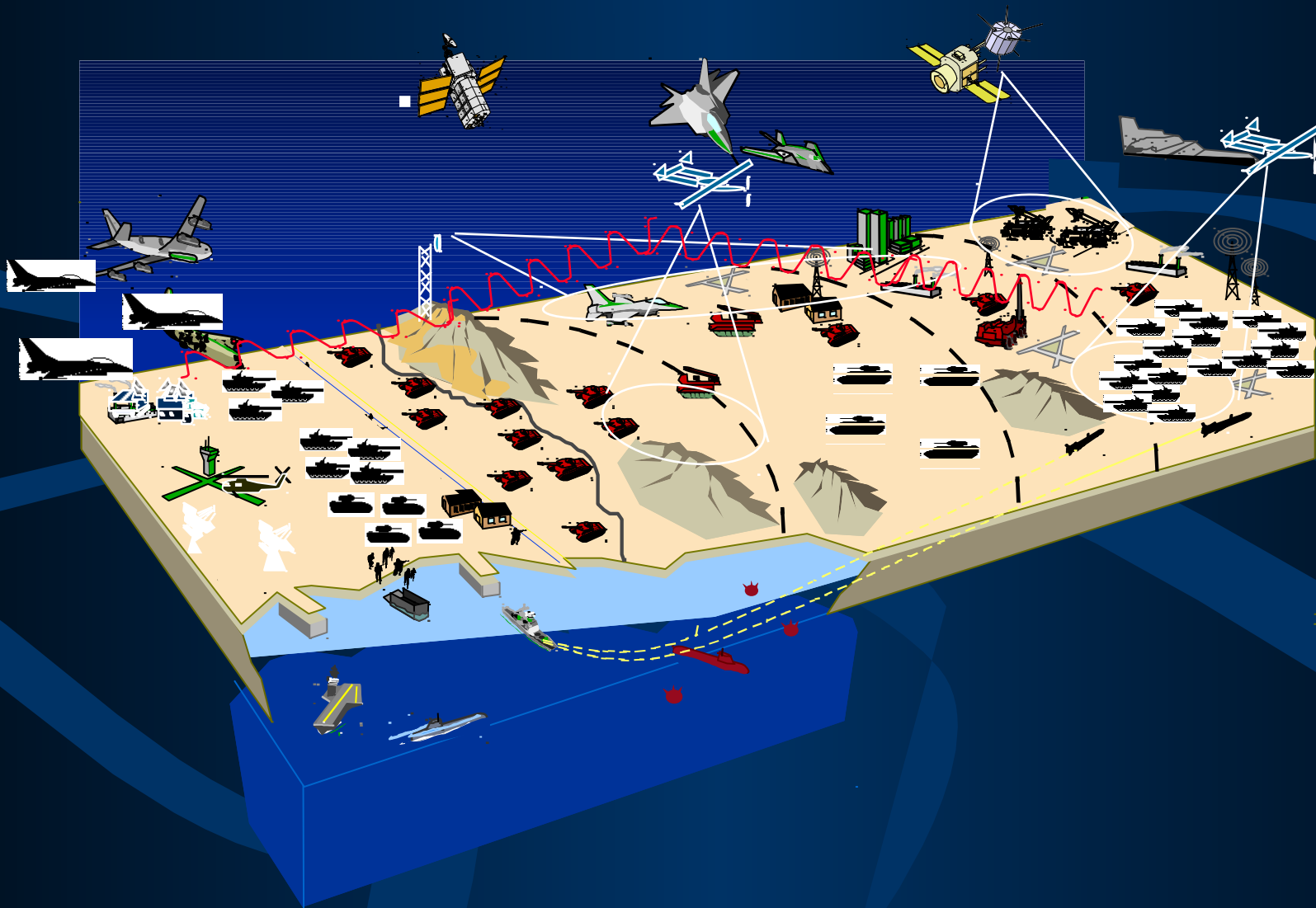


Validates human  
interface design

Provides visual models for understanding design

<http://www.bdi.com/index.html>

# Putting it all together in a simulated mission environment





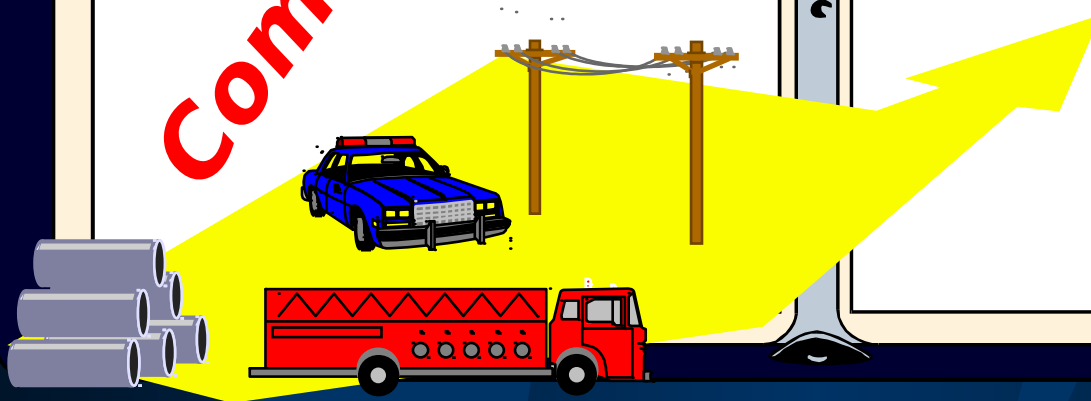
# Objective 5

**Common Services!**

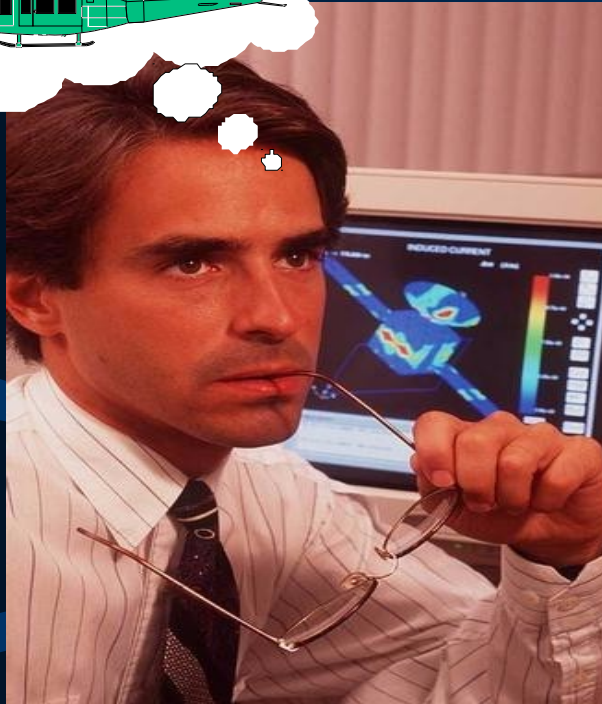
**VV&A**

**Repositories**

**Information Sources**



# Verification, Validation & Accreditation (VV&A)



**Verification - M & S Capability.** The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification.

DoD M&S GLOSSARY, Jan 98

**Developer: "Did I build it right?"**

# Verification, **Validation** & Accreditation (**VV&A**)



**Validation - M & S Credibility.** The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model.

DoD M&S GLOSSARY, Jan 98

**User: “Did I build the right thing?”**



# Verification, Validation & Accreditation (VV&A)



**Accreditation - The official certification that a model or simulation is acceptable for use for a specific purpose.**

**DoD M&S GLOSSARY, Jan 98**

**Accrediting Authority: “What is it Right For**

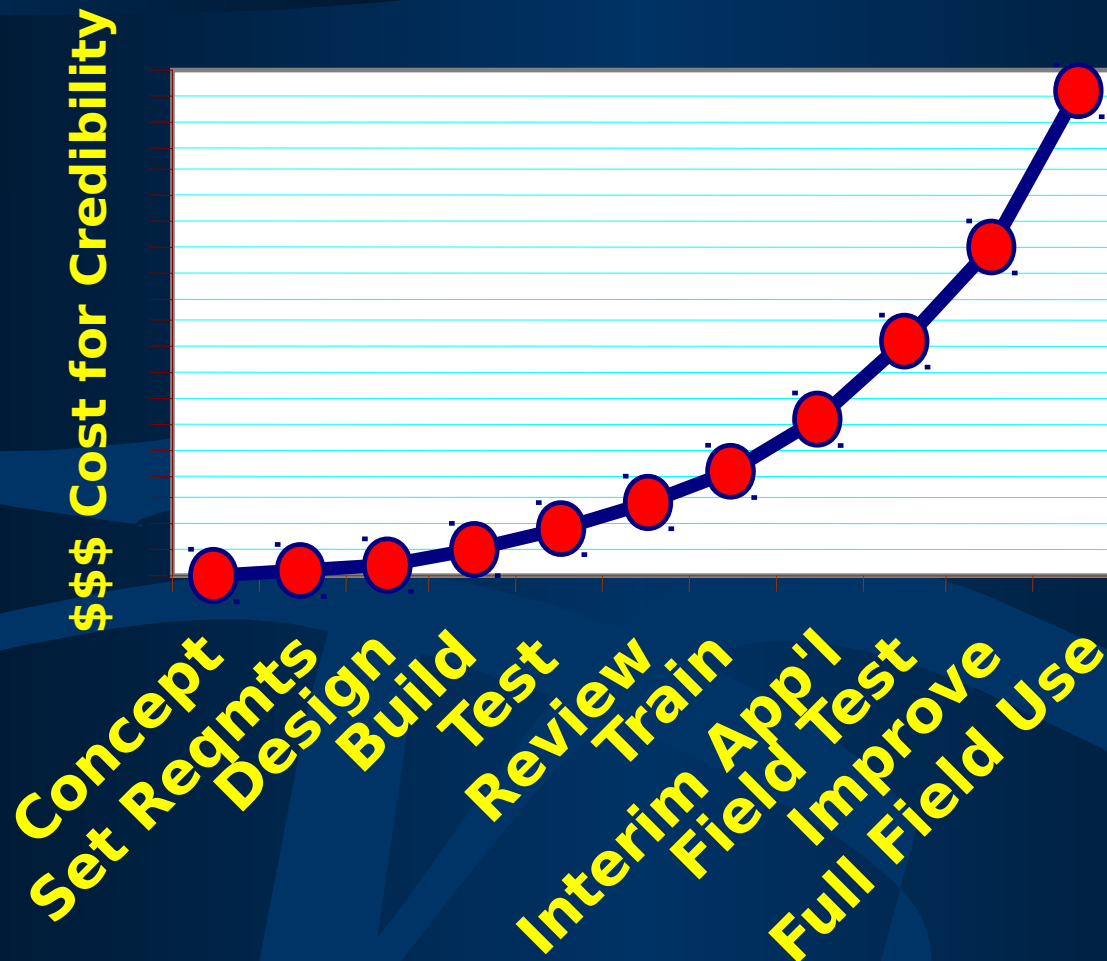
# Why Do VV&A?

- Increased **confidence** and quality
- Reduced **risk**
- Increased M&S **reuse**
- **Cost** containment
- Better **capability**





# VV&A Start Timeline vs. Costs



VV&A is a continuous process that starts at the beginning. *Cannot afford to wait until end* and say, "I want some of that VV&A."

# Resource Access is Confusing

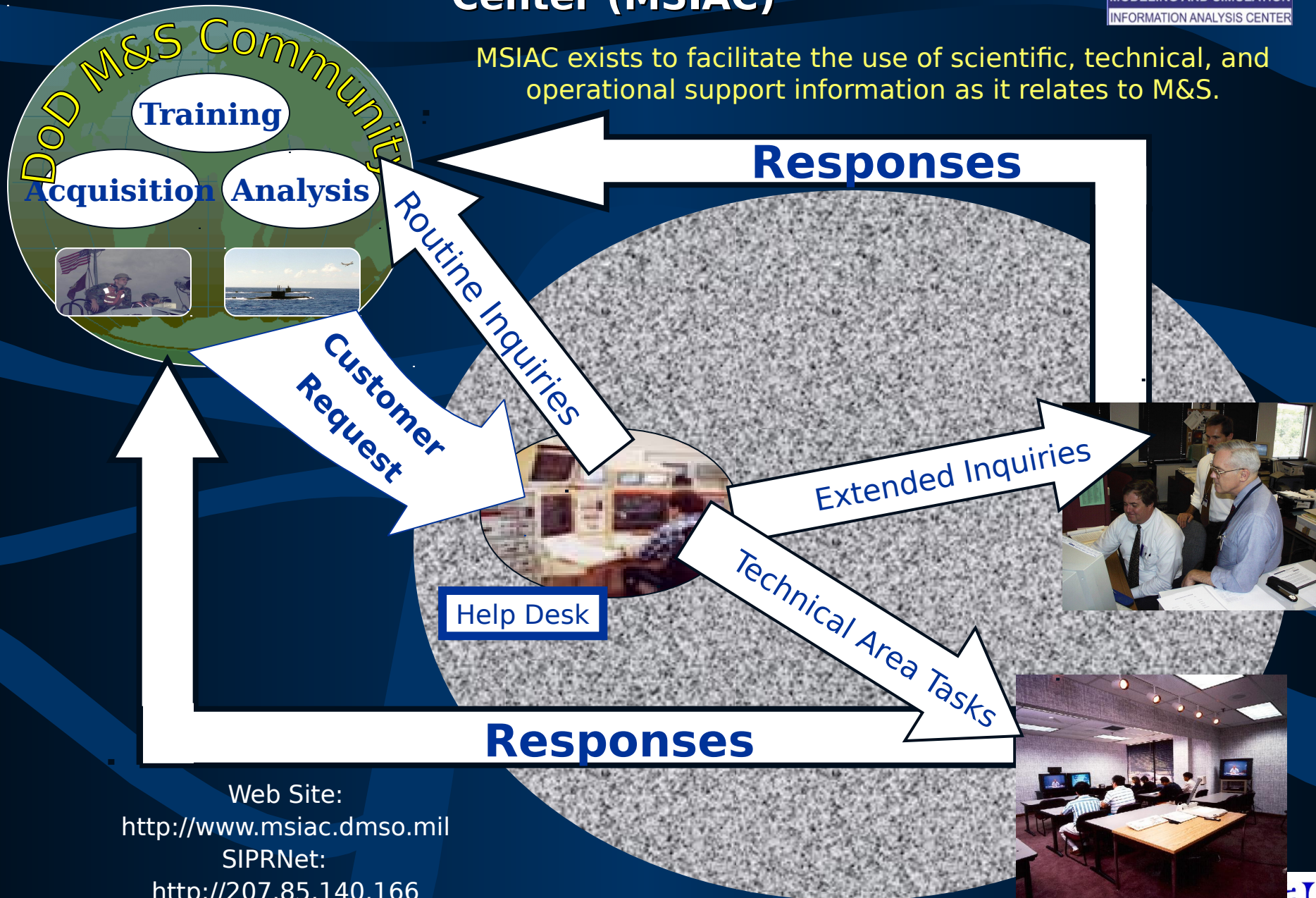


**Where can I go for  
help?**

# Modeling and Simulation Information Analysis Center (MSIAC)



MSIAC exists to facilitate the use of scientific, technical, and operational support information as it relates to M&S.



Web Site:

<http://www.msiac.dmsomil>

SIPRNet:

<http://207.85.140.166>

1-888-566-7672; [msiac@dmsomil](mailto:msiac@dmsomil)

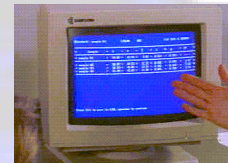
# M&S Resource Repository (MSRR)

- *A cooperative effort across the Department of Defense M&S community to enable sharing of resources*
- *A distributed network of servers, on both the Internet (unclassified) and SIPRNet (classified), sponsored by DMSO, with central access sustained by the MSIAC*

*The MSRR includes:*



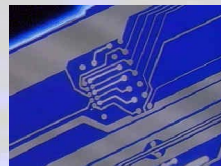
*A central catalog of resources*



*A search engine to index M&S related sites*



*An administrative and service infrastructure*



*A security system to prevent unauthorized disclosure of resources*

M&S Resource Repository: <http://www.msrr.dmsso.mil>

# Objective 6

**Share the  
Benefits of M&S!**

***Quantify Impact  
Education***



# Quantifying the Benefits of M&S





**Colleges**



**M&S Demo & Exhibits**



**Conference**

# Educating the Community<sup>s</sup>

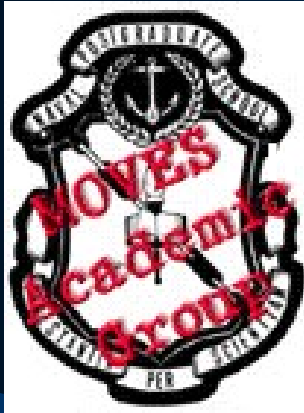
**Military  
Education  
n**



**DMSO  
Education and  
Training**



# Academic institutions focused on M&S



<http://www.npsnet.org/~moves/>

OLD DOMINION UNIVERSITY

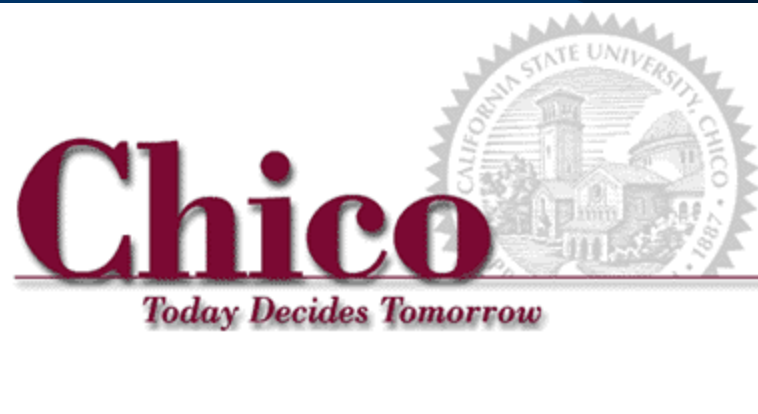


[www.odu.edu](http://www.odu.edu)



IST

<http://www.ucf.edu/>

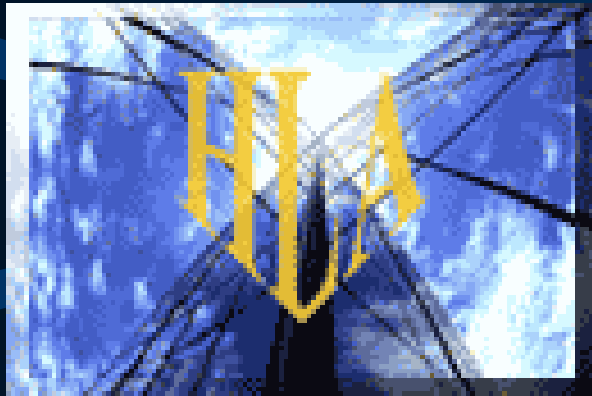


<http://www.ecst.csuchico.edu/~mcleod/courses/>

# M&S Courses



- M&S Staff Officer Course (MSSOC)
- DoD M&S Overview
- Program Management Office M&S Workshop
- MS 101
- NATO M&S Orientation
- Medical MSSOC
- M&S in RDA



- Regional Comprehensive introduction
- Implementer-level Hands-on training in use of HLA
- CD education



# Evolving M&S Education Programs

*Beginner*

*Experienced*

**Knowledge**

ADL  
Introduction

MS 101 and  
MSO

ADL

**Comprehension**

MSSOC

Warfighter M&S  
Course

**Application**

PMO M&S  
Workshop

Training  
Workshop

Analysis  
Workshop

Experimentati  
on Workshop

• T&E Course  
• RDA Course

JV 2020  
DOTML-PF

**Legend**

Existing

Planned

Out-  
years



# Conferences

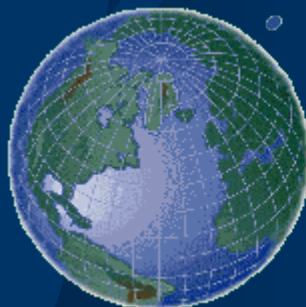
## Executive Forum on M&S



Interservice/Industry Training  
Simulation and Education Conference



Check the MSIAC  
web site "Links" for  
information on these  
and other M&S  
conferences



# SISO

Simulation Interoperability Standards Organization

[CALENDAR](#) [REFLECTORS](#) [SEARCH](#) [DOCUMENTS](#) [HELP](#)

 What's New

**msiac**  
MODELING AND SIMULATION  
INTEROPERABILITY AND COMMUNITY

# DMSO Web Site

[www.dmsso.mil](http://www.dmsso.mil)

Address <http://www.dmsso.mil/>

Back Forward Stop Refresh Home Search Favorites History Channels Fullscreen Mail Print Edit

File Edit View Go Favorites Help



## Lead, Integrate and Leverage M&S for the Warfighter

Welcome to the Defense Modeling and Simulation Office, or DMSO.

The DMSO's mission is to lead, integrate and leverage modeling and simulation (M&S) for the Warfighter. Since it was established in 1991 the DMSO has been a leader in guiding U.S. Department of Defense (DoD) M&S. We've come a long way, but given the maturity of DoD M&S today and the speed at which technology is changing, we have to be flexible and willing to shift our focus to fit the needs of the M&S community and serve the Warfighter.

To that end the DMSO was asked by the DoD Executive Council for M&S (EXCIMS) in March to reexamine its role. For details of our plan for moving out on the DMSO's new vector see the Director's Corner in the Spring edition of the [DMSO News](#). Or download the ["New Vector"](#) briefing here.

### What's New

[Summer Edition of DMSO News is online](#)

Click the title above to read updates on the new S&T Initiatives program,

**About DMSO**

**Enterprise Efforts:**  
Conceptual Models  
Data Engineering  
High Level Architecture  
Human Behavior  
Integrated Environment

**Community Support:**  
M&S Education  
MSIAC  
MSRR

**Warfighter Requirements:**  
VV&A

**S&T Initiatives**

**Resources:**  
Ask DMSO!  
DMSO News  
M&S Awards  
M&S Documents  
M&S Calendar

**LINKS**  
[USD\(AT&L\)](#)  
[DDR&E](#)  
[EXCIMS](#)  
[MSWG](#)  
[More...](#)



**Briefings Available Here**

Internet zone

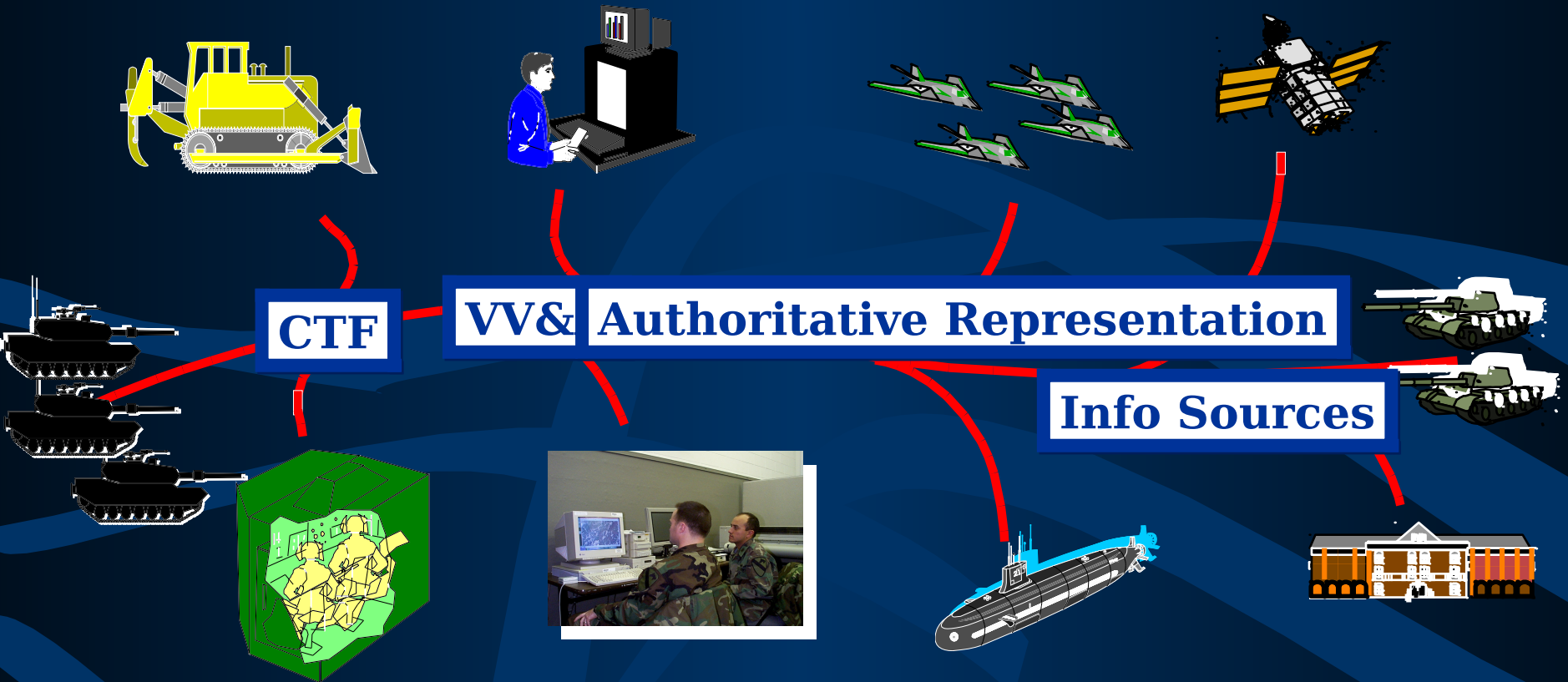
# Summary

- DoD mission environment is challenging and changing
  - Constrained resources
  - More and increasingly complex requirements
- Technology is a force multiplier; M&S is a key enabler
  - DoD M&S Master Plan, 1995
  - “City Planning” analogy; Six objectives
    - \* Common Technical Framework
    - \* Common Services

**INTEROPERABLE - REUSABLE - AFFORDABLE - CREDIBLE**

*Goal --  
Better Support to Warfighter*

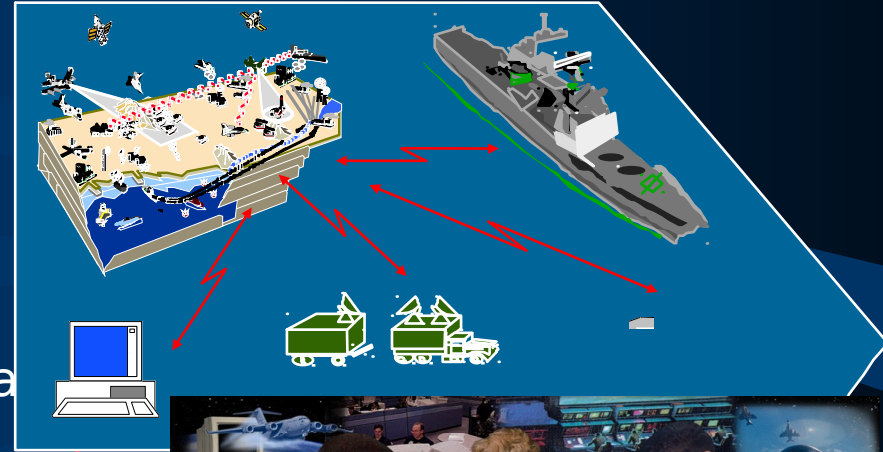
# Interoperability and Reuse !



"Sharing the Same Experience"

# The Future of Military Modeling and Simulation

- **Integrate** computer simulations, actual warfighting systems, and weapon system simulators.
- **Distributed** and connected.
- Warriors will use M&S:
  - to challenge **skills** at all levels of warfa
  - through the use of synthetic **environments**
  - representing every potential **opponent**
  - in any region of the **world**
  - with **realistic** interactions.
- **Acquisition** process: Use the same synthetic environments for research, development, and test and evaluation activities. May also use synthetic environments to support decision-making processes.





Simulation is a powerful tool that can be used  
for many ... situations, but like any tool,  
it needs to be wielded by skilled craftsmen  
with a clear vision of what they are  
creating and why.”

Jeff Loube, Managing Editor, MS&T Magazine  
Issue 1, 2001